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'Mir' Complex Continues Unmanned Flight

LD2905163789 Moscow TASS in English 1535 GMT 29 May 89

[Text] Mission Control Center May 29 TASS—The Mir orbital complex continues its near-earth space flight.

In the course of the unmanned flight the functioning of on-board systems and mechanisms of the space station is checked every day. Information is fed to the Mission Control Center by a number of scientific instruments. Specifically, a system for measuring the flows of micrometeorites and equipment for registering space radiation are functioning on board the space station. Experiments are being staged within the framework of a further study of the ionosphere and magnetosphere of the earth.

The research into out-of-atmosphere astronomy with the use of the international orbital observatory Roentgen will be started on May 30. it is planned to hold several observation sessions of the supernova in the Large Magellanic Cloud.

During astrophysical experiments the orbital complex is being orientated automatically with the help of the on-board computer, the platform-free inertia system and power gyroscopic stabilizers installed in the Kvant module.

According to the results of the trajectory measurements, the Mir orbital research station has the following parametres:

—Maximum distance from the earth's surface—423 kilometres,
—Minimal distance from the earth's surface—397 kilometres,
—Period of revolution—92.6 minutes,
—Inclination—51.6 degrees.

Former 'Mir' Crew Meets With Journalists

PM2905134089 Moscow PRAVDA in Russian 25 May 89 First Edition p 2

[TASS report: "Working Report From Crew"]

[Text] The crew of the "Mir" orbital space station, who completed their flight at the end of April, met with Soviet and foreign journalists at the USSR Foreign Ministry press center on 25 May.

A.I. Dunayev, chief of the USSR Main Administration for the Creation and Utilization of Space Technology, devoted his opening address exclusively to the problem of the effectiveness of our space program and announced figures which for many years had been kept secret from Soviet journalists and their foreign counterparts. The discussion turned immediately to our space budget.

In 1988, for example, the entire program of peaceful space research cost R1.3 billion. Revenue from the program, by all accounts, exceeded spending for the first time and reached R2 billion. As for total spending on the manned program in 1986-1989, A.I. Dunayev stressed, that was R1,471,000,000. This also includes spending on additional modules—the technological and gamma modules—which are being prepared for launch into orbit. True, the total economic effect of implementing the manned flight program during those years was not given. It was merely reported that a commercial income of $600,000 was obtained from payments for the performance of a number of technological and medical research studies to meet orders from foreign firms and for philatelic services.

Crew commander A.A. Volkov described the characteristics of the expedition and stressed its clear "terrestrial bias." In particular, by means of photographic and spectrometry apparatus photographs were taken to assess the condition of arable land and pasturage in Moldavia, the Ukraine, Krasnodar Kray, the Kalmyk Autonomous Soviet Socialist Republic, and Kazakhstan. The dynamics of the pollution of the Caspian, the Volga, and the Azov and Black Seas were studied.

Flight engineer S.K. Krikalev's account was equally interesting. Describing the exotically named "Tsirtseya," "Glazar," "Yantar," and "Era" experiments, he noted that they owe their contents to scientific and technical concerns on the ground. The work of the "Yantar" installation, for example, made it possible to devise a method for obtaining new composite materials.

The report from cosmonaut physician V.V. Polyakov contained interesting details on the functioning of the medical laboratory on board the orbital complex.

Update on Flight of 'Mir'

LD1506112889 Moscow TASS in English 1100 GMT 15 Jun 89

[Text] Moscow June 15 TASS—The Mir orbital complex continues its automatic flight. Geophysical experiments to explore the ionosphere and magnetosphere of the earth and measure the flow of micrometeorites in near-terrestial space are conducted regularly under the scheduled program.

Some 40 work sessions on exoatmospheric astronomy under the international Roentgen project, which besides Soviet scientists also involves specialists from Britain, the Netherlands, the Federal Republic of Germany and the European Space Agency, were carried out in two weeks of June.

The information obtained as a result of the observations of the supernova in the Large Megallanic Cloud shows that there has been a further drop in the intensity of the radiation flux of this unique stellar formation. Several series of experiments were also conducted to study the roentgen pulsar in the Centaurus constellation. The first measurements were made of the radiation of the nova in the Cygnus constellation, which exploded in the sky last month.

The on-board systems and scientific equipment of the Mir complex are operating normally.

Comment on New Cosmonaut Maneuvering Unit

LD2406015789 Moscow in English to Great Britain and Ireland 1900 GMT 23 Jun 89

[Text] The designer general of Soviet space apparatus, (Gay Severin), has told newsmen of a new device for astronauts' independent maneuver in raw space that's to be tested in a space expedition at the end of this or early next year. An independently operating motor will be fixed on the space suit to enable the spacemen to freely move within 100 meters from the spacecraft, changing his direction and speed. The device has been tested on Earth with the help of special air cushion simulators.

Research Continues Aboard Unmanned 'Mir' Station

LD0707121089 Moscow TASS in English 1114 GMT 7 Jul 89

[Text] Moscow July 7 TASS—By TASS correspondent reporting from the ground control center:

The orbital research complex Mir is continuing operation in an unmanned mode.

In keeping with an international program of astrophysical experiments called Roentgen, ground control conducted about thirty sessions observing the x-ray pulsar in the Vela constellation.

Starting on July 6, the telescopes of the orbital observatory have been directed at an x-ray nova that flared up in the Cygnus constellation.

The objective of the observations is to study the evolution of the temperature and the spectrum of irradiation of this unique celestial body.

Several geophysical experiments are conducted as the station is continuing its unmanned flight, using equipment that registers space radiation and a system that measures currents of micrometeorites in near-earth space.

According to telemetry informaton, the flight of the orbital complex Mir is proceeding normally.

Shatalov Discusses Need For On-Orbit Satellite Repair

LD0608165589 Moscow World Service in English 1500 GMT 6 Aug 89

[Excerpt] The head of the Soviet cosmonauts' training center, Vladimir Shatalov, has said the Soviet space exploration program is facing the need to set up an orbit-based satellite maintenance industry. He pointed out it was inexpedient to lose a satellite worth hundreds of millions of rubles just because one of its blocks [as heard] went out of order. It would be far more efficient to change the broken part in orbit so that the satellite could function much longer. Vladimir Shatalov said preparations for such experiments must begin already today involving spacecraft and cosmonauts.

Details Given on 'D' Module for Mir Station

18660201 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 2 Aug 89 p 4

[Article by G. Lomanov: "Into Outer Space with a 'Bicycle'"]

[Text] **"It is better to see it once than to hear about it a hundred times," said one of the colleagues when upon arriving in Zvezdnyy Gorodok [Star City] the journalists assembled around a full-scale mockup of the orbital space complex. One could sense irony in the voice, and not without reason. A visual demonstration is a good thing, but this time, perhaps, the saying had another meaning. Attached to the base block of the system—the "Mir" station—was the so-called, add-on equipment module "D". The very same module about which we had heard of more than once.**

The fact that the "Mir" is actually an inhabitable room in which real research will be conducted when scientific and technological modules moor at the station has been talked about in the press for four years now. The anticipation was obviously dragged out. Our newspaper reported the reasons for the delay in an interview with Yu. Semenov, corresponding member of the USSR Academy of Sciences and chief designer of spacecraft and space stations (SOTSIALISTICHESKAYA INDUSTRIYA,30 May 1989). It is not worth repeating the reasons, especially since we were ultimately given an opportunity to become familiar with one of the modules—an exact duplicate of the one which is planned to dock at the base block of the station this autumn.

Module "D" consists of three compartments—instrument-cargo, instrument-research, and airlock. Its maximum diameter is a little more than 4 meters, its overall length is 14 meters, and its volume is 60 cubic meters. The airlock, from which the crew will exit into outer space, seems quite small, but if it is compared to the transfer compartment of the station from which they exited, only one thing can be said—it is a mansion. A shower is provided in module "D"—which the "Mir" does not have—after intensive exercises all of the cosmonauts working on the station could only wipe themselves off with wet towels. This is bearable if a flight is planned for a week, but when an expedition lasts months....

The module has its own engines—if a fair amount of fuel remains after the docking, it can be used for maneuvering and orientation of the entire complex. Six gyrodines will help to stabilize the combination of docked space units, the same as those on the "Kvant," except that module "D" has them on the outside and not inside. Provision has been made for the possibility of mounting solar batteries—which will enable increasing

the energy capacity of the entire system. To mount them, it will be necessary for the cosmonauts to go out into space.

I hope that it will be clear from this short explanation why the new unit is called an add-on equipment module. As was noted by A. Viktorenko, the commander of one of the crews getting ready for the flight, module "D" will increase the comfort level of the system and will raise the volume of research work somewhat. Why a little? Familiarity with the research instruments with which the module will be equipped will help answer this question. "Volna-2" ["Wave-2"] is intended for the study of the flow of fluids in capillaries under conditions of weightlessness. "Inkubator-2" ["Incubator-2"] will be used to hatch quail eggs. The spectrozonal apparatus MKF-6MA—a modernized and automated MKF—is well-known to readers and has already worked on stations and even on the "Soyuz-22," which was specially equipped for it. There is one other photo camera—the KAP-350. And, finally, a rotating platform, manufactured in Czechoslovakia, is mounted on the outside of the module, just like the ones that were on the interplanetary "Vega" stations that investigated Halley's Comet. Pilot-Cosmonaut A. Serebrov expressed himself quite energetically with respect to the three television cameras installed on the platform: "It is time to put such equipment into a museum."

A fourth, more modern camera, will be delivered later by a cargo ship—it will also have to be installed by the cosmonauts in space. The "truck" will also deliver the already mentioned KAP-350 unit. Of course it is inconvenient to pull research equipment through several tight bays from one end of the complex to the other, and then mount it inside and outside, but there is nothing one can do. The launch weight of module "D" is about 23.5 tons—this is the maximum weightlifting capability of the "Proton" rocket.

And, finally, an SPK—system for moving in open space— will arrive at the module in orbit. Both the developers and the crew call it simply the "bicycle." Compressed air will move it. Thirty-two microengines will make it possible to perform very complex pirouettes in outer space. A person in a spacesuit who "mounts" an SPK is a kind of miniature spaceship which can cruise around for about 6 hours near the "Mir" station or the "Buran" spacecraft. The "bicycle" is intended first and foremost for the inspection of various objects—starting with satellites, which a large apparatus would have difficulty approaching—and ending with the "Buran," whose facing of brittle tiles cannot be approached as easily as the outer skin of the "Mir."

American austronauts tested a similar system a long time ago. They first worked on it on the "Skylab" space station, whose spacious bays permitted a little flying. Ours will have to be tested immediately in outer space and, therefore, a safety lanyard will be used for the first exits into outer space.

"The synthetic cord with a diameter of about 3 millimeters is very strong, and it will withstand any jerk, but it is not very convenient to move around with," says A. Serebrov. "The lanyard interferes with the dynamics of movement, and it is more difficult to steer the 'bicycle' with it."

Several test modes with the SPK in open space are planned. In the first, most cautious test, the cosmonaut will move away from the bay 5-8 meters and come back. Well, if all modes go smoothly, it will be possible to fly along the entire complex— from module "D" to the "Kvant." With a lanyard, a cosmonaut can move about 60 m from the base unit of the station, and without it, a good 100 meters. It will very likely be interesting to ride this "bicycle" in shoreless outer space. But we will not get ahead of our story, and we will wait until the module finally moors at the "Mir."

Journalists Briefed on Upcoming Cosmonaut Mission to 'Mir'

New Space Equipment Displayed

LD2807151789 Moscow Domestic Service in Russian 1300 GMT 28 Jul 89

[Text] Today in the Gagarin Cosmonaut Training Center there was a press conference for a large group of Soviet journalists. Our correspondent Vladimir Bezyayev also attended it.

[Bezyayev] Quite honestly, calling that meeting a press conference does not say anything. As far as I can remember, it is the first time that journalists have been given such an opportunity to get acquainted with new equipment, to ask absolutely everything they want, and most importantly to receive an exhaustive answer from any specialist, and not just to ask questions but to argue as well.

Lieutenant General Shatalov, head of the Cosmonaut Training Center did not just introduce to us the crews preparing for the next flight, but also told us in detail of the forthcoming program. Nobody avoided trenchant questions, for instance, on the significance of the space programs for the national economy and spoke honestly and openly of the difficulties which the cosmonauts might encounter, unforseeable difficulties — in other words, the risk.

The concrete reason for our meeting was to become acquainted with new models which, in the course of this year, are to supplement the orbital complex Mir. Module "D" [doosnashcheniye], for instance, will allow the crew the previously unseen luxury of showering every week. Through the airlock of this same module, and not through the hatch of the docking port, they will be able to go out for a long-distance walk in open space. To accomplish this, an SPK [sredstvo peredvizheniya kosmonavtov] has been created. We journalists still call it a space bike, but in essence, it is a small independent [avtonomnyy] spaceship which will make it possible for

the cosmonauts to leave and return to the ship, and to examine or repair artificial earth satellites.

Model "T" is decoded as "Technological." It is to fly in the second stage, and the name itself shows what it is destined for. A great deal of time is required to describe everything that has been seen and I will try to do that in a separate broadcast, including also the opportunity for you to hear the voices of those who in approximately one month are to take off from Baykonur.

Naturally, I will now list their surnames. Two crews are preparing for the launch. The State Commission still has to decide which of them will fly. But meanwhile I shall say that you know three of the cosmonauts well—that is Aleksandr Viktorenko, Aleksandr Serebrov, and Anatoliy Solovyev. The fourth is a person new to you; he is the ship engineer and already the third Aleksandr—Balandin.

The preparations for the flight are continuing.

Crews for Mir Mission Named

LD2807162389 Moscow TASS in English 1513 GMT 28 Jul 89

[Text] Stellar Township July 28 TASS—The next manned mission to a Soviet orbiting complex consisting of the space station Mir (Peace) and the research module Kvant (Quantum) is expected in the middle of next September and will last several months.

Briefing reporters on plans for the flight, Air Force Lieutenant- General Vladimir Shatalov, chief of the Cosmonaut Training Center in this town outside Moscow, said that two crews are preparing for it.

One is Colonel Aleksandr Viktorenko, the commander, and Aleksandr Serebrov, the flight engineer. The other pair is led by Colonel Anatoliy Solovyev whose flight engineer, A. Balandin, is the only space rookie among the four.

The crew who will go to the orbiting platform will receive two specialised modules, the first of which is to blast off in the middle of October.

The mission will also involve research in the interest of science and the economy and a space walk to test a manned maneuvering unit using engines based on compressed air cylinders and enabling a cosmonaut to move about in the vicinity of the platform.

Leonov Comments on New Mission To 'Mir', Plans For 'Buran' Flights

LD1508190789 Moscow TASS in English 1835 GMT 15 Aug 89

[Text] Star City, Near Moscow, August 15 TASS—By TASS correspondent Rena Kuznetsova:

The launch of cosmonauts to the Soviet "Mir" orbital station is scheduled for September 6, Alexey Leonov, deputy head of the Cosmonaut Training Center, told journalists here today. He presented the crew who are to dock with and work at the "Mir" orbital station. These are Aleksandr Viktorenko and Aleksandr Serebrov. The second crew of Anatoliy Solovyev and Aleksandr Balandin were also present.

The last expedition of three cosmonauts completed work at the space complex on April 27, 1989. Since then the station has been in an automatic flight. And prior to them, Soviet cosmonauts Vladimir Titov and Musa Manarov logged a year onboard the space station—the longest period anyone has remained in orbit.

Among the spacemen presented at the meeting, Aleksandr Balandin is the only newcomer. He was born in Fryazino, near Moscow, in 1953, graduated from the Bauman higher technical school in Moscow and was enlisted in the group of cosmonauts in 1978. He underwent training under the "Buran" reusable spacecraft flight program.

Serebrov said that two modules are planned to be ferried to the station. The first, a service module, should be launched in October and the second, technological, will be docked with the complex in January-February 1990.

The service module will deliver a space bicycle, a device with whose aid cosmonauts will be able to move around the station by getting away from it at a distance of 50 meters. An updated man-manoeuvering unit, Orlan, was developed for work on the bicycle. The technological module has a device which will enable it to accommodate the "Buran" in future.

Answering the question on the prospects for using the "Buran," Leonov said that a pilotless launch of this reusable spaceship and its docking with "Mir" is planned for 1991. Two variants of its return to the earth are under consideration: With the crew or independently. Leonov said that the manned flight of the shuttle is planned in 1992.

'Astron' Space Observatory Research Program To Be Concluded

LD2206174389 Moscow TASS in English 1708 GMT 22 Jun 89

[Text] Moscow June 22 TASS—The Soviet space observatory "Astron" which was meant to exist for a year has been in space for six years, reporters were told at the scientific test center today. A meeting of the state commission that supervised the satellite's flight was held there. As reserves of gas in the engines for orientation and stabilization were running out, and since solar batteries, because of a long stay in the aggressive space medium, were functioning worse, the panel of specialists decided to conclude the scientific program and sum up its results before the satellite goes out of order.

As many as 100,000 commands were sent to the satellite from the ground in six years of its operation. Only eight of them have not been performed. Six hundred twenty-eight communications sessions were held instead of the planned 230. Spectra of 130 stars were registered by means of the ultraviolet telescope created by Soviet and French scientists.

The ultraviolet telescope was trained not only on stars, but also on galaxies and nebulae, on Halley's Comet that passed close to the earth and other comets. Discoveries have been made. For instance, an unusually large number of hot stars was discovered in the galaxies.

Using an x-ray telescope, astronomers witnessed for the first time how pulsars are increasing and decreasing in size which is accompanied by variations in their brightness. Astronomers also observed the rotation of neutron stars, the gradual change in the duration of the travel of pulses of X-ray emission from pulsars.

The results of the work were published in more than 40 scientific journals and were reported at 12 international scientific meetings.

The new space observatory "Granat" is now being created on the basis of Astron's stand-bys. The new observatory is to be put in orbit at the end of the year.

Academician Boyarchuk Comments on 'Astron' Program

LD2706195789 Moscow Domestic Service in Russian 0800 GMT 27 Jun 89

[Text] The Soviet satellite Astron has completed its research program. It was placed in orbit in 1983 and researched distant worlds. Our correspondent has interviewed Academician Aleksandr Alekseyevich Boyarchuk, head of the scientific part of the project.

[Begin recording] [Reporter] Aleksandr Alekseyevich, Astron worked in orbit for 6 years. What new things has mankind found out about our universe as a result?

[Boyarchuk] In this age it is very difficult to discover something absolutely new. Individual phenomena which shake the world happen very rarely—superconductivity, for example. But as far as more specific, purely scientific work is concerned, we have obviously obtained a great deal of material. When we started this work in 1975, we did not expect such great success. We have a lot of data about unstable stars, we have much data about an exploding supernova in the Magellanic Cloud. In particular, we have interesting data about the chemical composition, about the dynamics of the envelope.

There were also interesting observations of Halley's Comet. We monitored its approach, in effect, for almost a whole year at various comet-Earth and comet-Sun distances. Molecules left its surface in a variety of ways and disintegrated under hard radiation from the Sun. The investigation of clear spectra, without atmospheric interference, allowed us to estimate the loss of mass resulting from the evaporation from the nucleus of the comet that was recorded by the Vega and Giotto probes. And on the whole, having monitored a fairly large part of the trajectory, we were able to establish the loss of mass during one revolution. And thereby we were able to estimate how many such revolutions around the sun it will take—how much longer the comet will survive. And according to our estimates, in approximately 30 revolutions there will be no more Halley's Comet. Thirty revolutions is about 2,000 years. Of course there will be the nucleus which will continue to go around but there will be no tail. It's all going to evaporate in the course of its earlier travels. This is of cosmological significance. It follows that the comet was captured comparatively recently, perhaps 30,000 years ago. But in astronomical age 30,000 years is next to nothing.

[Reporter] When the station was launched you were counting on it working for a year. Anyway, that was the guaranteed time. But the station worked for 6 years.

[Boyarchuk] Well, first of all, why a year? The year applied to the component base. It would not let it move any longer. As far as scientific programs were concerned, we set up a reserve scientific program and the durability of the probe allowed us to react well and quickly to all the new astronomical phenomena that arose suddenly.

[Reporter] The conclusion of the commission says that the station carried out a volume of research which is normally planned for two or three probes. Do you agree with that?

[Boyarchuk] Yes, I agree with that, because it was planned that we would have some 200 communications sessions during 1 year, while altogether we had 600 sessions.

[Reporter] This was the first observatory. Do you think that this work should be continued?

[Boyarchuk] We are proceeding along the right road. That such work should be continued is also shown by the fact that the Americans, for example, have built their space telescope—an extremely expensive telescope—some $600 million. But they went ahead and spent it.

UDC 524.352.7

Hydrodynamic Investigation of the Supernova 1987A in the Large Magellanic Cloud: Cooling Wave Phase

18660143a Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 15, No 2, Feb 89 (manuscript received 28 November 88) pp 99-108

[Article by V. P. Utrobin, Institute of Theoretical and Experimental Physics, Moscow]

[Abstract] Because the explosion of a supernova and the stellar evolution that precedes it are such complex phenomena, only their general features have been studied to any great extent. This hydrodynamic study of supernova 1987A represents a departure in the narrowing of its focus to the relationship between the light curve and effective temperature of the supernova, on the one hand, and the density distribution, chemical composition, mass, radius, and explosion energy of the progenitor, on the other. Eight hydrodynamic models of the explosion are examined. Agreement between one of the models and the observed light curve indicates that the structure of the outer layers of the progenitor—the blue supergiant Sanduleak-69°202—had a density distribution very similar to that of the polytropic model with an index of n = 3; its mass was roughly equal to 11 solar masses. On the basis of the effective temperature of the supernova in the cooling wave phase, the author concludes that the outer layers of the progenitor had a chemical composition with a mass fraction of hydrogen of about 0.1, and of helium, about 0.9. Figures 4, references 16: 1 Russian, 15 Western.

UDC 524.35.7

Interpretation of Radio Emissions From Supernova 1987A in the Large Magellanic Cloud

18660143b Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 15, No 2, Feb 89 (manuscript received 8 Apr 88) pp 109-117

[Article by V. N. Fedorenko, Physical Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] Radio emissions were unexpectedly observed two days after the optical maximum of the 23 February explosion of supernova 1987A. Observations on four centimeter-range frequencies are interpreted, and a model is constructed on the basis of four points: (1) The mechanism of radiation is the synchrotron process, with relativistic electrons emitting in the region in which R_{S2} is less than or equal to r, which is less than or equal to R_{S1}. (2) The observational dependences $F_\nu(t)$ advanced by Turtle *et al* are explained by the transition from synchrotron self-absorption to radiation in the optical region in which $\tau_S(\nu)$ is much less than 1. (3) Relativistic electrons are accelerated in the vicinity of the shock wave front when r is roughly equal to R_{S1} by a mechanism of the Fermi I type. (4) The magnetic field of H about 0.1 gauss when R_{S2} is less than or equal to r, and r is less than or equal to R_{S1}, is several times greater than in the region in which r is greater than or equal to R_{S1}; the field in the wind is a Parker spiral. Figures 1, references 14: 7 Russian, 7 Western.

UDC 550.312:551:523.42

Relief of the Crust-Mantle Boundary and Strain-Compression Stresses in the Crust of Venus

18660143c Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 15, No 2, Feb 89 (manuscript received 19 Oct 88) pp 182-190

[Article by K. I. Marchenkov and V. N. Zharkov, Institute of Terrestrial Physics, USSR Academy of Sciences, Moscow]

[Abstract] Venutian spherical harmonics of topography correlate with the corresponding harmonics of the nonequilibrium portion of the gravitational field when n (the order of the spherical function) is greater than or equal to 3. Relief is isostatically compensated. The absence of global system of ridges, rifts, or subduction zones suggests that Venusian convection is locked in a thick, unsubmerged crust. Convection in the upper mantle is apparently independent of convection in the lower mantle, has a structure of a considerably smaller scale than on Earth, and is probably poorly reflected in the longwave portion of the gravitational field of the planet. It follows that the longwave portion of that field for spherical harmonics in which n is greater than or equal to 3 and which correspond to relief harmonics stems from variations in the thickness and, possibly, the density of the crust, and not from convective currents in the mantle. The authors present the results of an analysis of the crust-mantle boundary (Mohorovicic discontinuity) and the strain-compression stresses that is based on the data and assumptions given above. Some of the Venutian models they study make allowances for an athenosphere—a liquid, nonviscous layer inside an elastic shell. The Moho undulation amplitudes for the various models vary from about +80 km (down) to about -20 km (upward). The crust-mantle boundary is found to be rather smooth, and stresses range from about +600 bars for strain to about -700 bars for compression. Figures 2, references 15: 11 Russian, 4 Western.

Solar Flares of 5 November 1980 as a Result of Magnetic Reconnection on the Separator

18660144a Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 66, No 1, Jan-Feb 89 (manuscript received 10 Jul 87) pp 105-113

[Article by V. S. Gorbachev and B. V. Somov, Moscow Engineering Physics Institute; Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] In focusing primarily on the processes associated with the propagation of heat flows and accelerated particles along two interacting x-ray loops, studies of the two solar flares of 5 November 1980 have failed to answer three important questions that reflect the gap between the simple two-dimensional models of the primary accumulation and release of energy and the actual observed three-dimensional flare picture: (1) Were the loops a consequence of the flares, or the cause of them? (2) What caused the flares to occur where they did in the active region, and why did the loops appear where they appeared? (3) What explains the fact that the flares were two-ribboned, which seems to contradict the model of interacting loops? In addressing those questions, the authors set out to determine the kind of observational picture that an energy release on the separator would produce. Using a coronal model of the potential magnetic field of the AR 2776 active region that assumes that the quasistationary heating of the loops over a 15-hour period was due to continuous dissipation of the magnetic field, with anomalous conductivity, they demonstrate that the same topological features of the separator that are important to the formation of a current sheet are responsible for the typical observational features of the flares of 5 November 1980. The ribbons and loops are judged to be a result of the topological structure of the magnetic field in the vicinity of the separator. Figures 6, references 30: 10 Russian, 20 Western.

Estimation of Thickness of Venusian Lithosphere From Its Gravity Field

18660144b Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 66, No 1, Jan-Feb 89 (manuscript received 16 Feb 87) pp 120-125

[Article by Yu. A. Tatakanov, N. Sh. Kambarov, and V. A. Prikhodko, Institute of Earth Physics imeni O. Yu. Shmidt, USSR Academy of Sciences; Moscow State University]

[Abstract] In an examination of the gravity anomalies of Venus, 19 sources are isolated in which dynamic compression is positive, i.e., the sources are compressed along the radius of the planet and have a horizontal radius of 5-7°. Depth of the geometric centers ranges from 620 to 1240 km, with an average of 920 km. Discrepancies of mass and harmonic coefficients are small, and none of the sources makes any appreciable contribution to the flattening of the planet. The sources may be a result of deep-seated, latent heterogeneities whose motion is due to convection of nonuniform flow or a result of lithospheric deformations whose folding distorts the deep-mass field. The authors' own work and the work reported in the literature suggest that the flattening of Venus is ancient, a notion that correlates well with the depth of the sources if the thickness of the lithosphere is taken to be equal to the average depth of the sources, i.e., around 900 km. The high surface temperature of the planet may also point to a thick, dry thick lithosphere. Figures 1, references 12: 3 Russian, 9 Western.

UDC 531.36

Stationary Motions of Axisymmetric Satellite in Circular Orbit

18660165a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 28 Apr 88) pp 176-179

[Article by M. Z. Abulnaga]

[Abstract] In an earlier article by M. Z. Abulnaga, et al. (ASTRON. ZHURN., Vol 56, No 4, 1979) stationary solutions were found for the problem of translational-rotational motion of a satellite in the field of attraction of sphere. These solutions correspond to "oblique" positions of relative equilibrium of the body. This article gives stationary solutions of the restricted problem in the case of an axisymmetric satellite. It is shown that if a satellite whose center of mass moves in a circular non-Keplerian orbit has an axis of dynamic symmetry, the equations of rotational motion allow two groups of stationary motions. The first group consists of two special solutions in which the axis of symmetry lies in the orbital plane: one solution when the axis of symmetry deviates by a small angle from the radius vector and a second when the axis of symmetry is precisely directed along the tangent to the orbit. This group has only orbital rotation with the velocity n. The second group consists of two more general solutions in which the axis of symmetry deviates from the orbital plane by an arbitrary constant angle: one solution when the axis of symmetry is in a plane deflected from the normal plane passing through the radius vector by a small angle, and another, when the axis of symmetry lies in the plane passing through the tangent normal to the orbit. In these cases there is both orbital motion and characteristic rotation about the axis of symmetry with a stipulated velocity. Figure 1; references: 5 Russian.

UDC 629.785

Decomposition Method in Near-Planetary Astronavigation Problem Using Pseudostars

18660165b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 27 Aug 87) pp 221-227

[Article by V. F. Petrishchev]

[Abstract] The decomposition of measurement space was performed in a near-planetary astronavigation problem, including the zenith distances of two stars and the angular diameter of a planet, for the case of decomposition of state space into the four-dimensional subspace of intraplane and two-dimensional subspace of exoplane parameters of motion. Measurements of the zenith distances of two sighted stars are converted to the zenith distances of two pseudostars, the direction to the first of which coincides with the current transversal, whereas the direction to the second coincides with the binormal to the plane of the a priori orbit. As a result of

decomposition the intraplane parameters are evaluated using measurements of the zenith distance of the first pseudostar and the angular diameter of the planet; the exoplane parameters are determined from measurements of the zenith distance of the second pseudostar. Expressions are derived for elements of the corresponding navigation matrices. Figures 3; references: 4 Russian.

UDC 533.951

Narrow-Band Electromagnetic VLF Emission From Electron Fluxes in Ionosphere and Magnetosphere

18660165c Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 7 Jul 87) pp 228-231

[Article by N. I. Izhovkina, S. A. Pulinets and N. M. Shyutte]

[Abstract] A theoretical model of narrow-band electromagnetic VLF emission is proposed for natural conditions with allowance for the spectrum of spontaneous electromagnetic bremsstrahlung of electrons and instability of the distribution function of electrons relative to the pumping of waves polarized in the direction of rotation of electrons in the external magnetic field. It was found that the fundamental resonance in the emission of electron whistlers is a resonance with a normal Doppler effect. The increment of electron whistlers was determined for a temperature-anisotropic distribution function of magnetospheric electrons (including the skin layer). A theoretical model of narrow-band electromagnetic VLF emission from electron fluxes in cosmic plasma is briefly described. Irregularities on the tail of the distribution function of electrons trapped by the magnetosphere may be the reason for generation of the narrow-band spectrum of VLF waves. On the other hand, these irregularities may be intensified (or blurred) during multiple interaction with narrow VLF packets, depending on the the dispersion properties of plasma and structure of the geomagnetic field. Figure 1; references 11: 5 Russian, 6 Western.

UDC 550.385.41

Diffuse Auroral Zone. IX. Equatoral Boundary of Diffuse Precipitation From Plasma Sheet as Boundary of Large-Scale Convection in Magnetosphere (Plasmapause)

18660165d Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 7 Jun 88) pp 232-247

[Article by V. S. Solovyev, Yu. I. Galperin, L. V. Zinin, L. D. Sivtseva (deceased), V. M. Filippov and V. L. Khalipov]

[Abstract] A three-dimensional, time-dependent model of the distribution of thermal plasma in the inner magnetosphere in the nighttime sector local time is proposed. The model is based on the concept that the boundary of diffuse precipitation is a boundary of large-scale magnetospheric convection, that is, an instantaneous plasmapause. The results of comparisons of model computations and experimental profiles of electron concentration of thermal plasma in the plasmasphere in most cases indicated a satisfactory agreement with respect to prediction of the L-shell of considerable drops of electron concentration inside and at the boundary of the plasmasphere. These results in general confirm representation of the boundary of diffuse precipitation, and accordingly the plasmapause, as an Alfven layer: a narrow band of sharp change in the characteristics of convection caused by screening of the large-scale electrical field of the magnetosphere at this boundary. Since the intensity of the ascending flux of thermal ions is largely determined by the difference in the concentration of thermal plasma near the equatorial plane from an equilibrium concentration, the proposed outer plasmasphere model makes possible a more precise determination of the upper boundary conditions in solving problems in modeling of the ionospheric F-region, involving allowance for longitudinal fluxes of thermal ions in a tube of force. Figures 7: references 50: 17 Russian, 33 Western.

UDC 551.510.535.2

Parametric Generation of ELF Waves and Ion Acceleration During Injection of Strong VLF Waves Into Ionosphere

18660165e Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 16 Dec 88) pp 248-257

[Article by V. M. Chmyrev, M. M. Mogilevskiy, O. A. Molchanov, Ya. P. Sobolev, Ye. Ye. Titova, T. A. Yakhnina, R. N. Suncheleyev, V. A. Gladyshev, N. V. Baranets, N. V. Dzhordzhio, Yu. I. Galperin and A. V. Streltsov]

[Abstract] Data from the "Cosmos-1809" satellite were used in demonstrating that the propagation of a strong whistler VLF wave through the ionosphere is accompanied by the generation of ELF waves and the acceleration of ionospheric ions. The excitation of emissions correlated with VLF pulses of the ELF transmitter occurred in the frequency range 70-400 Hz with an intensity maximum about 8×10^{-6} V/m $Hz^{1/2}$ at frequencies 140-180 Hz. Simultaneously with the generation of ELF emissions there was a broadening of the spectrum of initiating signals of the VLF transmitter by about 200-400 Hz. The intensification of the ion flux in the zone of the VLF effect occurred in the energy range 15-700 eV. The intensity was maximal for energies 20-70 eV and was 2-4 x 10^4 cm^{-2} x s^{-1} x eV^{-1} x sr^{-1}. The fluxes of accelerated ions are anisotropic.

The experimental results are attributable to the mechanism of acceleration of superthermal ions by electromagnetic iono-cyclotron waves generated in ionospheric plasma with parametric instability of whistlers. Figures 7: references 19: 10 Russian, 9 Western.

UDC 533.9

Change in Parameters of Anisotropic Interplanetary Plasma on Front of Magnetohydrodynamic Shock Wave

18660165f Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 8 Sep 87) pp 258-266

[Article by S. A. Grib and B. A. Khrapov]

[Abstract] On the basis of use of an open system of dynamic compatibility equations a numerical study was made of the change in the parameters of interplanetary plasma at the front of a magnetohydrodynamic shock wave (the structure of the front was not investigated). Possible variants of change in plasma parameters are studied for weak and strong magnetic fields, reflecting conditions in solar wind plasma and within the Earth's magnetosphere. It is shown that allowance for pressure anisotropy can be very important when studying the changes in the parameters of interplanetary plasma on the front of a fast nonstationary shock wave because in an anisotropic case a series of new regularities is manifested, and in particular, with k = 6 or greater, the field strength increases to a greater degree than density. An initial strong magnetic field exerts a considerable influence on change in plasma parameters on the shock wave front in comparison with a weak field. In an anisotropic case the magnetic field change at the shock wave front is less than in an isotropic case. Figures 4; references 34: 15 Russian, 19 Western.

UDC 550.385.41

Narrow Ionization Troughs in F Region Determined From Measurements From 'Cosmos-900' Satellite and Their Comparison With Surface Ionospheric Observations

18660165g Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 19 Jun 87) pp 267-271

[Article by V. V. Afonin, V. M. Fillipov, L. V. Shestakova and V. N. Alekseyev]

[Abstract] Some cases of registry of narrow ionization troughs on the "Cosmos-900" satellite are examined and are compared with data from vertical and return-slant soundings of the ionosphere by the Yakutsk meridional chain of stations. The surface ionospheric observations were analyzed for those moments in time when the satellite registered narrow troughs in the latitudinal distribution of electron concentration near the meridian of ionospheric radio sounding surface stations. The narrow (about 100 km) troughs registered by the satellite spatially coincide with a sharp electron temperature increase. The magnitude of the electron temperature jump is dependent on the difference between the electron density value in the narrow trough and the background and is usually 500-3000 K. A comparison of satellite and surface measurements (sounding ionograms) reveals that over the observation station there was a narrow jet of a fast westerly ion drift. It is concluded that the narrow troughs in N_e observed by satellite were caused by this mechanism. The sharp T_e increases in the region of narrow ionization troughs are evidently attributable to the influence of strong electrical fields on F-region plasma. Further research is required for understanding the nature of the complex physical mechanisms which are responsible for such a sharp and local jump in electron concentration. Figures 3: references 12: 9 Russian, 3 Western.

UDC 550.383

Dynamics of Flux of High-Energy Solar Particles Near Large-Scale Solar Wind Disturbances

18660165h Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 20 Aug 87) pp 272-279

[Article by V. Ye. Timofeyev, V. V. Klimenko, I. P. Bezrodnykh, Ye. I. Morozova, N. F. Pisarenko and I. A. Transkiy]

[Abstract] On spatially separated space vehicles an experimental study was made of the dynamics of fluxes of solar particles in the frequency spectrum of fluctuations of the interplanetary magnetic field. This made it possible to determine the parameters of propagation of charged particles near large-scale solar wind structures of the shock wave type. The article gives an analysis of the results of measurements on the "Venera-13" and "Venera-14" spacecraft during the period 7-10 December 1982 and 5-9 January 1983. It was found that the dynamics of the fluxes is essentially dependent on the physical nature of the scattering sources determining particle transport processes in different propagation media. During the analyzed period interplanetary space was stratified in its scattering properties. Data on increase in the flux of solar particles were used in numerical estimates of free paths in the undisturbed solar wind and behind the front of the interplanetary shock wave. The presence of a considerable anisotropy in the increase phase in the event of 5-6 January 1983 was associated with the diffusion of particles within the "quasitrap" formed by the propagating shock wave. Figures 3; references 12: 6 Russian, 6 Western.

UDC 535.24:523.6

Origin of Dust Component of Halley's Comet

18660165i Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 3 Feb 88) pp 280-285

[Article by L. M. Mukhin, T. V. Ruzmaykina and A. D. Grechinskiy]

[Abstract] An effort was made to ascertain the place of origin of Halley's comet and whether the dust component of the comet is interstellar matter or a product arising as a result of the condensation of hot gas in the protoplanetary disk. The following data are examined: the radical difference between the mineral part of cometary dust and meteor matter, the possibility of survival of the organic mantles of dust particles in the process of formation of the protoplanetary disk and also the difficulty of formation of dust particles with a silicate nucleus and an organic mantle in the protoplanetary disk itself. The formation of complex organic compounds in dust particles would require irradiation of a mixture of ices by UV or X radiation or cosmic rays in a dose which they probably would not receive in the Oort cloud. The particles analyzed during the last cometary transit, in particular, clearly received a dose of ionizing radiation which is greater than could have been received in the Oort cloud. On the other hand, definite evidence indicates an interstellar origin of these cometary particles. Figure 1; references 17: 2 Russian, 15 Western.

UDC 551.521.8

Research on Spectral Characteristics of Light Nuclei on 'Cosmos- 1571' Artificial Earth Satellite

18660165j Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 10 Jun 87) pp 313-316

[Article by A. B. Akopova, V. G. Ambartsumyan, V. Ye. Dudkin, L. V. Melkumyan, Yu. V. Potapov and Sh. B. Rshtuni]

[Abstract] A study was made of the energy distributions of one- and two-charge particles with an energy of several tens of MeV per nucleon in circumterrestrial orbit. Data were collected using photoemulsions on the "Cosmos-1571." The flight was made during the period 11-26 June 1984 (apogee 420 km, perigee 355 km). New procedures were used in the development and analysis of the photoemulsions. In contrast to the traditional method, the new procedures ensure considerable acceleration of the process of accumulation of the necessary experimental material, there is no need to apply special coordinate grids to the emulsion surface and the new threshold development method considerably facilitates inspection of the emulsion and selection of the necessary events. The differential energy spectra for one- and two-charge particles with energies up to 50 MeV per nucleon which were registered are analyzed in detail and compared with the data of other authors. There are three main sources of these particles in orbits with an altitude not greater than 500 km (galactic cosmic ray particles, radiation belt particles and secondary particles generated during interaction between galactic cosmic ray and radiation belt particles and nuclei forming part of the detector and the surrounding instruments and shielding). The contributions of these sources are estimated. Figures 4; references 9: 7 Russian, 2 Western.

UDC 551.593

Slitless Spectrum of Ionospheric Emission Layer Registered Aboard 'Salyut-7' Orbital Station

18660165k Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 5 May 87) pp 316-318

[Article by Yu. V. Platov, N. Ya. Vanyarkha and V. I. Kulidzhanishvili]

[Abstract] The slitless spectrogram method is applicable in spectral investigations of objects having relatively small angular dimensions in at least one direction. The method combines the advantages of filter observations and the use of spectrographs, with simultaneous registry of a considerable part of the spectrum in a single frame. The instrumentation used in the Soviet-French program for photographing the night sky was supplemented by a diffraction grating which is attached to the camera objective, making it possible to use it as a slitless spectrograph. This instrument was used in the autumn of 1985 aboard the "Salyut-7" in test spectral observations of different objects. A slitless spectrogram was obtained of the emission layer at about 100 km, and another of the lights of a city not far from the horizon. The dispersion on the film when using an objective with a focal length of 50 mm was 288 A/mm. The processing of the photographs involved determination of the wavelengths of the individual emissions in the spectrum of city lights and in the emission layer. Mercury and sodium lines were found in the spectrum of city lights, whereas the red forbidden line of atomic oxygen and the line 5890 Na were detected in the emission layer. Photometric sections were also run along the direction of dispersion in the red, green and blue parts of the spectrum. Due to the lack of calibration of the photographs it is not yet possible to make quantitative estimates of the intensities of the registered emissions. Figure 1; reference: 1 Western.

UDC 535.24;523.42

Analysis of General Circulation of Venusian Atmosphere

18660166 Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 5 Sep 86) pp 286-291

[Article by S. S. Zilitinkevich]

[Abstract] An analysis of general circulation in the Venusian atmosphere was made using a rough representation of the temperature field based on three parameters: global mean value, mean vertical gradient and equator-pole horizontal difference. The first two of these parameters are evaluated directly on the basis of published temperature measurements and the third is evaluated indirectly on the basis of data on velocity of the zonal wind. The process of development of the convective boundary layer in the daytime atmosphere is examined. It is shown that the computed scale of thickness of the atmospheric boundary layer (8 km) virtually coincides with the observed thickness of the lower layer of adiabatic stratification and weak winds, slightly changing with altitude. This confirms the convective nature of the ABL on Venus. Despite the degeneration of convective turbulence in the nighttime hemisphere, the quasihomogeneous layer caused by the convective ABL phenomenon should almost invariably persist in the diurnal variation (that is, in longitude). Venus rotates sufficiently rapidly that the diurnal temperature changes are negligible in comparison with the latitudinal variations so that conditions on the planet are favorable for a symmetric circulation of the Hadley type. References 15: 9 Russian, 6 Western.

Positional Observations of Satellites of Mars in Mt. Maydanak Observatory in 1988

18660163 Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 15, No 3, Mar 89 (manuscript received 9 Nov 88) pp 270-276

[Article by S. B. Novikov, State Astronomy Institute imeni P. K. Shternberg, Moscow]

[Abstract] Between July and October 1988, good image quality and special measures taken to reduce light scattering enabled State Astronomy Institute researchers at the Mt. Maydanak Observatory of the Lithuanian Academy of Sciences Institute of Physics to produce 737 images of Phobos and 792 of Deimos with the 1-meter reflector. Good images are difficult to obtain because of the proximity of the moons to the planetary disk, whose brightness is so much greater than that of the moons. Instead of using the conventional Hall screen to block out the light of the planet, the researchers used a special mask to merely suppress the light (by 600 times). They were thus able to produce an image that pictured Mars as well as its satellites. The positional observational data obtained were compared with those obtained by Born and Duxbury (1975) and Duxbury and Callahan (1988), as well as Shor (1976). Figures 2, references 8: 4 Russian, 4 Western.

Interview With Col-Gen Maksimov, Deputy Chairman for Buran Launch

18660169a Moscow GRAZHDANSKAYA AVIATSIYA in Russian No 4, Apr 89 pp 22-23

[Interview by GRAZHDANSKAYA AVIATSIYA correspondent with Col.-Gen. Aleksandr Aleksandrovich Maksimov, deputy chairman of the State Commission for the Rocket and Space System Energiya-Buran and chief specialist of the USSR Ministry of Defense for Reusable Rocket and Space Systems and the Prospects of Their Development: "A Happy Moment"; first paragraph is source introduction]

[Text] On the eve of the Cosmonauts Day, our special correspondent V. Gorkov met with the deputy chairman of the State Commission for the Rocket and Space System Energiya-Buran and chief specialist of the USSR Ministry of Defense for Reusable Rocket and Space Systems and the Prospects of Their Development, Col.-Gen. A. A. Maksimov. We submit the interview for your reading.

[GA]: *Aleksandr Aleksandrovich, allow me on behalf of all the specialists of Aeroflot to congratulate you on this holiday, Cosmonauts Day, and to wish you success in your labors.*

[Maksimov]: Thank you. And, you know, I think this holiday has actually gone far beyond the pale of a trade holiday. It has become everyone's holiday. And when it comes to the specialists of civil aviation, they are, by and large, part of the same team with us in the business of the development of the manned Soviet space program. So I'd like to take this opportunity in turn to congratulate you, too—our esteemed aviators—on this genuinely national holiday.

[GA]: *This year, it's special. All the Soviet people waited anxiously for Buran's first flight. And then the flight took place. It was entirely natural that a wealth of articles were published about it. And among them were some that posed the question, Just how much do we need Buran? What can you say about that?*

[Maksimov]: In such cases, it's useful to turn to history. At the dawn of the development of the space program, this country's first satellites and manned spacecraft were lifted by launch vehicles right into working orbits. Then came the time when the direct placement of vehicles and satellites no longer met our needs, because it didn't meet the needs of our new goals. The further development of launch vehicles and orbiting space facilities followed. Those vehicles and others produced additional power capabilities that made it possible to place space vehicles into working orbits a step at a time, that is, by using intermediate orbits. That, along with standardization, enabled a more effective use of the capabilities of space equipment.

Let's take, for example, the Tsiklon launch vehicle. The range of the weights that it can lift is 550-4000 kg. Its third stage can be switched on twice and can lift satellites into near-circular orbits of altitudes of 200-3600 km; for elliptical orbits, it can place them even higher—up to 8,000 km. That's excellent. And the same can be said of the Proton launch vehicle, which is being used to place geostationary satellites and unmanned interplanetary vehicles into orbit. And yet, that's not enough, if you look to the future.

At present, a new type of space equipment is coming about and is letting us know more and more about itself—so-called transport-technical service equipment, which includes interorbital towcraft, booster units, and equipment for docking, transporting, servicing, and repairing space vehicles. Take the problem of setting up orbital stations. Mir, and after it other, larger orbital structures, will have to be built in orbit, which will require extensive transport operations in space.

The problem can be solved only by creating a highly developed, reusable transport system. Energiya-Buran is the first-born of that system, and, at the same time, it is its foundation. It represents, I would say, the re-birth of the Soviet space program. We associate it with the space program's progress in the future. To stop, to give up what we've achieved would be wrong. To say the least, future generations would not forgive us.

[GA]: *All the same, if we may continue on this topic—in connection with the changeover of all the sectors of the national economy to cost-accounting and self-support, more and more often we hear the cries about the poor efficiency of space equipment that doesn't even produce much for the national economy, about huge expenditures, and so forth. Just how correct, in your view, are the authors of such claims?*

[Maksimov]: What can I say? The problems of space research cannot be made utilitarian. By what yardstick do you measure the expenditures for, say, the creation of efficient space facilities to monitor adherence to various international treaties? Or what kind of equipment does it take for the discovery of the supernova that was found in the Large Magellanic Cloud in 1987 and for the observation of its evolution? But even take ecological issues, and national economy issues, and other issues that the space program is involved with only very indirectly. In general, name just one new,improved object—say, the hydrofoil—on whose development would be earmarked fewer monies than the previous ones. Another matter is that further reduction of its cost depends largely on mass production. As for Buran, its new technology is the result of the contribution made by the industry of the entire country, by many of its sectors. By the way, the special trainer complex on which the automated landing of the spacecraft was perfected was also used successfully in civil aviation, in the development of the new Tu-204 passenger airliner. It is too bad that the sector's mass media are rather sparing in their reportage of this.

I would add that Mikhail Sergeyevich Gorbachev, when he was at the Baykonur cosmodrome in May 1987,

perspicaciously noted that the Energiya-Buran rocket and space complex creates the prerequisites for a qualitative and quantitative changeover. That's why we consider this system a scientific and technical breakthrough to new technologies, to new infrastructures in the design of space equipment, and, as a result, to their becoming less expensive, to the benefit of society.

[GA]: *As we can see, the development of Buran is pursuing particularly peaceful, economic goals. What is the role of military specialists in this matter?*

[Maksimov]: We, of course, like the military specialists in the United States, are interested in a new rocket and space transport system that is capable of lifting into near-Earth orbit communication, navigation, TV, and weather-observation satellites, as well as satellites for monitoring the performance of international treaty obligations. But, as has been reported time and again, the idea of "star wars" and transforming space into a theater of military operations is basically foreign to us. And to view Buran in a military context completely misses the point.

[GA]: *Aleksandr Aleksandrovich, as everyone knows, the launch of Buran involved an enormous amount of work. All the events are described in rather extensive detail. And yet, we would like to hear some additional details. Even if it's just about the work of the state commission of which you are a member.*

[Maksimov]: First of all, I want to note that none of us members of the commission had ever before tackled work of such a scale in his life. To describe this unprecedented preparation in 25 words or less would be to say nothing and to offend the people. This is a special, immense topic.

But I can talk about a few of the moments we had. The first time, it was 28 October 1988, and the heavy steel doors of the launch structure bunker had closed at 2100 hours Moscow time. The situation outside appeared rather calm. The state commission and the technical management were working crisply, confidently, and cheerfully. Nevertheless, everyone felt the extreme tension.

Everyone knows what happened on the morning of 29 October, 51 seconds before the start. It was, of course, a pity that the "stop" signal was sounded because of a basically trivial problem, and tens of thousands of people began to work back. But nobody was dejected—just the opposite, there was a desire to finish what they had started. After all, everyone recognized that our space program was on the threshold of a new epochal event.

On 10 November, the preparations for the new launch are practically finished. But we decide that a day or two wouldn't do the weather in. We needed to let the people get some rest, some sleep, and then get back to work in a good mood. But the elements almost did do the "weather" in...

And then again, on 15 November 1988, we're in the bunker. The "re-start" is going briskly, smoothly, but the weather conditions are deteriorating not with every hour, but with, literally, every minute. We wanted the cyclone to hold off or just pass to the north of us. But Nature has its own laws. A weather reconnaissance airplane is observing conditions within a 300-km radius and is reporting the latest data. Weather reports are coming in every half hour.

The leadership of the state commission climbs to the booster start control room and takes their places behind the technical managers. The time is approaching to press the 10-minute-to-automatic-start button. And suddenly there's a snag...A weather specialist puts a report about a storm warning on chief launch-vehicle designer B. Gubanov's desk and asks him to sign off. Gubanov gets up and goes over to the technical management for the control system, which, after evaluating their reserves, gives the "OK." Then Boris Ivanovich goes to the state commission leadership. This whole procedure took place in front of everyone's eyes. Seconds of exhausting anticipation are passing, and from the gestures and even the facial expression and tilt of the head of the "chief," we understand that the decision may be made to launch. It's more like we agree with his suggestion. You would've had to have seen, in those few minutes, Gubanov's charming smile and his excitement as he sat down next to Maj.-Gen. V. Gudilin and gave the command to launch.

The seconds ran by on the collective-use board...The fatal fifty-first second went by...And then the fiery storm on all the television screens indicated the start of the rocket and space system. Now all eyes were on the Flight Control Center. How is the combined propulsion unit of Buran working? Reports are coming in...Finally, both switch-ons had occurred, and the vehicle was in orbit. The time had come for a small respite, and our thoughts turn to how the craft will behave upon landing. The service vehicles and engineering equipment pull out to the landing strip. Only they are allowed to leave shelter, since their crews will have to be the first to approach the craft and begin the technical servicing of it.

Fifteen minutes before the landing, Deputy Chairman of the USSR Council of Ministers I. Belousov, CPSS Central Committee Department Head O. Belyakov, Minister of the Aviation Industry A. Systsov, and I get permission to leave from State Commission Chairman Vitaliya Khusseynovich Doguzhiyev, and we rush to the landing complex. You can't imagine how bad the weather was! An icy, 20 m/sec wind was literally knocking us off our feet, but all any of us had on our mind was Buran, although we know that the wind for it along the landing strip is not scary. Finally, just like a hydrofoil, the spacecraft glided down along the glide path and softly ran along the strip. The specialists surround it and perform the stopping procedures and the cooling of the landing gear. And there it stood proudly, waiting for the last bit of fuel to burn out from the auxiliary propulsion system, and there were bright flashes coming out of the

tail section. By the way, of the 38,000 ceramic tiles, each of which is certified with its own specifications and is affixed to a specific spot, only four fell off over the course of the entire flight.

And so, the first Buran holiday ended. There will be a second, more complicated flight. Then the craft will be controlled by the crew.

There, on the strip, next to Buran as it cooled off, all of us again felt an unusually keen sense of national pride and of joy for our country. It's hard to convey what that ineffable joy was like! One such moment makes it worth being alive and working.

Preparations for Buran Launch

18660169b Moscow GRAZHDANSKAYA AVIATSIYA in Russian No 4, Apr 89 pp 23, 26

[Article by V. Karashtin, doctor of technical sciences, professor: "Getting Ready for the Launch"]

[Text] The readers probably remember that on 15 May 1987, in the Soviet Union, the first launch was made of the versatile, heavy-duty Energiya launch vehicle and its engineering mock-up payload. The size and weight of the vehicle, the power of its engine, and the need for a high degree of accuracy in payload placement and for operational reliability placed incredibly stringent requirements on prelaunch preparations and launch.

And now exactly one and one-half years later, to the day, as they say, on 15 November 1988, the second launch of Energiya has taken place. Only this time it was carrying not an engineering mock-up payload, but a real reusable orbital craft by the name of Buran. Did the time span of a year and a half represent a long time, or a short time? For those who simply awaited the next launch, it was, of course, a long time. But for the specialists and all those who were working under stress, that span of time flashed by as if it were just a second.

An important feature of the engineering schedule for the launch preparations for the versatile Energiya rocket-and-space transport system is that there are a great many processes going on at the same time, and they must precisely synchronized in time. Only a high degree of automation of all the prelaunch preparations and of the launch have made that possible. If the automated launch-complex control-system plays the leading role in the synchronization during the initial period of preparations and in the fueling stage, then that role goes over to the ground-based and on-board equipment of the control system for starting the engines and for flight the minute that preparations begin for start-up of the on-board monitoring and control systems. That equipment is switched-on 20-30 minutes before the launch and operates according a strict time schedule. A failure in the operation of any system during this last stage results in a change in the time of launch or to postponement of the launch. Hence the extremely strict requirements for reliability in the systems associated with the preparations.

The 29 October 1988 postponement of the launch of Energiya graphically illustrated that. The automated system for prelaunch preparations made a timely and precise identification of a delay in the separation of the transfer deck with the azimuthal guidance instruments of the flight control system gyroplatforms from the rocket; then it issued the command for automatic cessation of preparations (ACP). To put it bluntly, the "ACP!" report that was issued over the PA system practically froze everyone who was in the control bunker in their tracks. After all, there were only 51 seconds to "We have lift-off," which already signals the beginning of flight.

In such a situation, there is, technically, only one thing that can be done—dump the fuel components and bring all the Energiya and Buran systems back to their original state. Which, strictly speaking, is what was done.

Preparations for launch require the synchronous operation of systems not only of the launch complex, but also of other ground complexes of the spaceport.

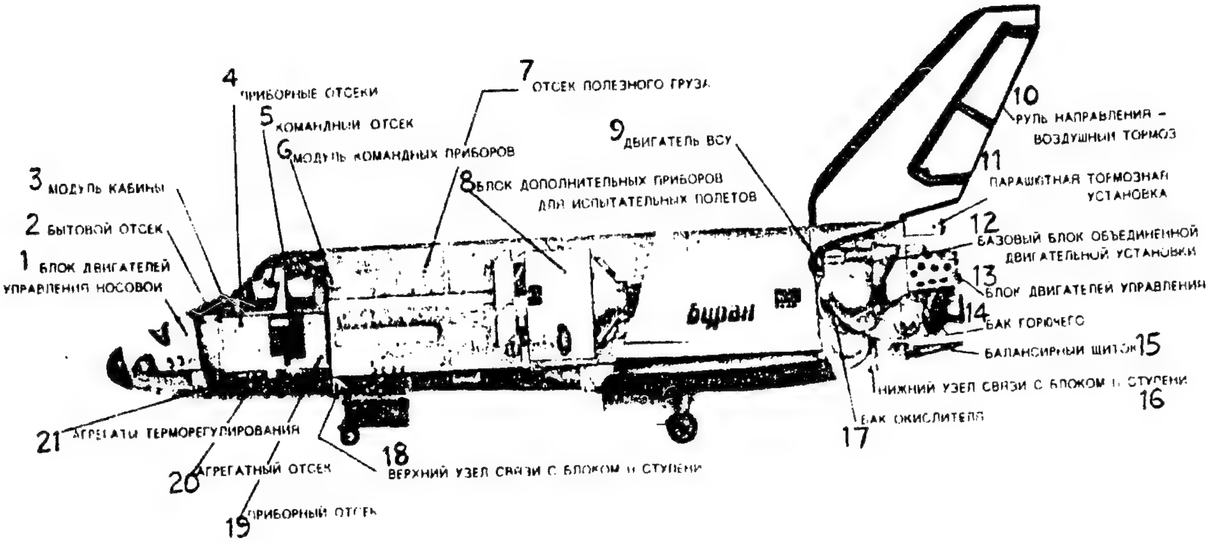
The main thing that is needed from those systems for the beginning of the launch preparations is that they support the launch, the landing complex of Buran, and the work of all other services that ensure the provision of electrical power from two independent sources that back each other up. The complexity of the task stemmed from the unusually large amount of power they must provide. In a word, it's equivalent to the electrical power consumption of a rather large city.

At the same time, the weather service goes into action, providing a constant forecast of the weather for the launch date and, on the day of the launch, hourly weather reports and forecasts for the launch site, the Buran landing complex, and the entire powered segment of the flight trajectory.

When any rocket is being launched for the first time—and especially one like Energiya—favorable weather conditions are always desirable. Much to our chagrin, the weather situation on 15 November was not favorable. An hour before launch, there was even a storm warning. A check of the actual wind velocity showed it to be just barely acceptable. Nevertheless, the decision to launch was made.

Just before the beginning of the prelaunch preparations—the fueling—the launch director received the reports on the readiness of the measurement sites at the spaceport and along the flight path to receive and process telemetry, as well as readiness reports from other services supporting the launch.

Then the process itself of prelaunch preparations began at the launch complex. From that point on, all the other complexes and services worked synchronously on the



Key: 1. Control thruster (forward)—2. Crew living compartment—3. Cabin module—4. Instrument sections—5. Control compartment—6. Command instruments module—7. Payload bay—8. Block of supplementary instruments for test flights—9. Auxiliary power unit engine—10. Control rudder - air brake—11. Braking parachute unit—12. Base unit of consolidated propulsion unit—13. Control thrusters—14. Fuel tank—15. Body flap—16. Lower attachment point with second stage—17. Oxidizer tank—18. Upper attachment point with second stage—19. Instrument section—20. Equipment section—21. Thermal control equipment

same time schedule, which is completely determined by the processes associated with the progression of the launch preparations for Energiya and Buran at the launch.

The launch complex consists of a number of structures spread out over a large area for purposes of their mutual safety in the event of an emergency situation either inside the structures themselves or outside them arising from rocket failure at launch. The starting device, on which Energiya sits and from which it is launched, consists of a reinforced-concrete structure with mechanisms for securing the launch vehicle in place and with devices for making pneumohydraulic and electrical connections. Beneath the starting device is a deep chute with three gas ducts for removal of the gas streams of the propulsion units during the start-up of the vehicle.

Several seconds before the start of the engines, streams of water are fed into the openings of the starting unit in order to reduce the acoustic factors that are caused by the operation of the propulsion units. During the initial segment of flight, the streams of water are fed upward, in order to lower the factors.

Complex technical problems that had to be dealt with for the first time ever were encountered in the development of the fueling systems, especially those that handled supercooled liquid hydrogen. The storage units for the cryogenic fuel components—liquid hydrogen and oxygen—consist of spherical tanks with baffle-and-vacuum separation. Because the components are especially highly explosive, the tanks are kept a great distance from the starting device, on which the launch vehicle sits. Less-explosive components and compressed gases are kept closer. During the fueling of Energiya and Buran, in which more than 4,000 actuators had to be controlled, all 10 tanks of the launch vehicle and the one of Buran were filled. That required having on hand extremely accurate information about the mean temperature of the supercooled hydrogen, as well as information that could be used to see that the component level in each tank deviated by no more than tens of millimeters.

Pneumohydraulic and electrical hook-ups of the ground systems and the launch vehicle were made through the vehicle's end and its side surface by means of a fueling-and-venting tower that has mobile platforms. Those platforms have supply lines for fueling and venting, as well as electrical cables that provide the "ship-to-ground" communications. According to the engineering schedule, those platforms are pulled away one by one, and the last, which has a hydrogen venting pipeline, is pulled away only after the engine starts and the vehicle begins to move. The platform weighs more than 20 tons and takes several seconds to be pulled away. The difficulty lies in the fact that such a huge mass must be braked and smoothly stopped during those same few seconds.

Why is there a need for the so very complex technology associated with the pulling away of the last platform? Because the liquid hydrogen being fed into the tank "vaporizes," and those vapors must at no time mix with air. Otherwise, an explosion is inevitable. The pipeline for removing the vapors from the launch vehicle is laid

right on the platform. Therefore, the pipeline must not be pulled away for any reason until the rocket begins to ascend. Most of the hook-ups between Buran and the ground systems were made through the end of its tail section and were disconnected by the motion of the craft.

The automated launch-complex control system is based on a hierarchical arrangement and has three levels, with a total of more than 100,000 issuable commands and receivable signals.

The next important problem that had to be solved, especially for the first launches, was the production real-time information on the parameters of pneumohydraulic and other systems of the launch vehicle. Three second-level systems were used for that. The first operated on the principle of remote measurement, which enabled technicians and developers to continuously track the variation of parameters during preparation and to document the more important segments. The two other systems used the principle of remote measurement, with documentation of the preparation, plus subsequent processing of data in real time in order to bring it up on displays.

Systems for controlling, measuring, and monitoring engineering processes such as the storage of fuel components and gases constitute a special class of systems. They provide for storage, and during fueling they control the feed to the inlet of the launch vehicle. They differ from the automated launch-complex control system in that the functions of control and monitoring in them are combined in one system based on a specially developed microprocessor. Their algorithm of operation is programmed with traditional computer techniques, and then those programs are entered into permanent memories. The memory programs can be changed right at the spaceport, which forms the basis for on-line entry of changes that become necessary in the process of finishing up the prelaunch preparations.

No small amount of attention was devoted to safety matters during the launch preparation. The significance of such measures for the Energiya launch vehicle and for the entire launch complex stems from the fact that liquid oxygen and liquid hydrogen—two components that are incompatible from the standpoint of safety—were used as fuel components. For that reason, design, engineering, and organizational measures that precluded their mixture were taken aboard the launch vehicle and at the launch complex.

The compartments of the Energiya launch vehicle in which hydrogen and oxygen vapors could appear are equipped with low-inertia gas analyzers capable of issuing the proper signals if the vapor concentration exceeds the established norms. A gaseous nitrogen is fed into the compartment from which the signals are issued, the amount of the gas being delivered varying (it increases, and then it decreases) with the signal level of the gas analyzer. Similar measures have also been taken in the compartments of the Buran orbital craft.

The system of engineering-related television was a great help in the provision of information to the directors of the launch preparations. It enabled remote visual inspection of virtually any external part of the launch vehicle and of ground equipment units.

The same sort of system visually monitored the pulling away of ground equipment from the launch vehicle just before launch and during launch. as well as the start-up of the propulsion units and the initial segment of the flight of Energiya and Buran.

Flight Controller and Deputy Designer Describe Buran Flight

18660169c Moscow GRAZHDANSKAYA AVIATSIYA in Russian No 4, Apr 89 pp 26-28

[Article by V. Kravets, Buran flight controller and doctor of technical sciences, and O. Babkov, deputy general designer: "Expectations Were Fulfilled"]

[Text] And so, on 15 November 1988, the Soviet Union witnessed the first flight of the Buran reusable orbital craft, which was placed into orbit by the versatile Energiya launch vehicle. As has already been noted, that remarkable event was preceded by a colossal amount of work performed by hundreds of design, scientific research, and production groups from many sectors of the national economy.

We should note that our country began working on the creation of a reusable spacecraft much later than did the Americans. When the work on the Shuttle was in the developmental stage in the United States, the principal efforts of our industry and scientific development were focused primarily on the creation of the long-term orbital stations Salyut and Mir, nonreusable transport craft for servicing them, and modules for increasing the levels of scientific and applied research. Our achievements in that area of the space program are well-recognized. From the very beginning of the design process, the overall design of the Soviet reusable system, as well as the order of its flight tests, has differed considerably from that of the American craft.

The American configuration of the reusable space system is as follows: booster motors plus central fuel tank plus orbital stage. That design is less versatile and more pragmatic, with maximal reusability of the main elements of the system and with piloted flights beginning with the first launch. It virtually precluded use of a payload other than the orbital craft. Such an approach forced the designers to place the main engines of the system on the orbital stage. In addition, use of solid-fuel booster motors with virtually unrectifiable malfunctions after launch required a colossal amount of debugging on the ground and led to the false assumption of a factor of safety equal to unity. As the Challenger tragedy confirmed, such a factor of safety is not just theoretically unachievable.

On the other hand, the piloted flights that began with the very first launch made it possible to simplify somewhat the Shuttle's automatic landing equipment, since on the last, near-Earth leg of the flight, the crew of the ship performed the landing from an altitude of less than 10 kilometers.

Our configuration consists of a two-stage Energiya launch vehicle with parallel stages and with the Buran reusable orbital craft or some other large payload of about 100 tons attached to the launch vehicle bundle. Although this design for a reusable system is somewhat inferior to the American system in terms of reusability, it is, on the other hand, much more versatile. Among other things, it enables independent in-flight development of the launch vehicle, which was successfully done with the first launch of Energiya on 15 May 1987.

Out of considerations for the safety of the crew, the first experimental flight of the Soviet orbital craft was, from the very beginning, designed as an unmanned flight, which is customary for the Soviet space program. The commencement of the flight tests of Buran in a pilotless version forced the designers to completely automate all its flight operations, from preorbital maneuvers to landing and taxiing along the landing strip of the airfield.

As the press has already noted, many of the characteristics of the Energiya-Buran system are unique. It has a launch weight of nearly 2,400 tons; the most powerful engines in the world in the strap-on units of its first stage, each with a thrust of more than 800 tons; second-stage hydrogen-oxygen engines; automated "airplane" landing of the orbital craft; and much more.

The Energiya-Buran control system is also unique. It is the first Soviet manned spacecraft to depend completely on on-board computer complexes designed on the basis of highly productive computers of the same type.

Let's pause briefly on the systems of the orbital craft that are directly associated with flight control. Experience garnered earlier in the development of unmanned and manned space vehicles with computers on board was used in the creation of the Buran control system. The practice of flight control of orbital stations and nonreusable transport craft indicates that an ever increasing volume of tactical management tasks must be transferred to the on-board complex and to the crew of the ship. Thus, left to the Flight Control Center and the ground personnel is the handling of tasks of strategic planning, control in unforeseen situations, and the development and interpretation of scientific and national-economy experiments and research.

With Buran, the possibility is realized for loading the sequences of all the necessary flight operations and their variations in emergency situations that are required for automated execution of flight programs into the on-board computer center while still on the ground, during the launch preparations. Moreover, if need be, the craft's flight program can be changed from the Flight Control Center through the command radio link.

The flight safety control system is conferred with special functions. The liquid-fuel engines used in the first and second stages of the Energiya booster have made it possible to design an automatic system for identifying malfunctions in them, shutting the malfunctioning engines, and making optimal use of the remaining power in the booster and the craft. It should be noted that such a system is virtually impossible in its full form in the American reusable system, because of the use of solid-fuel boosters in the first stage.

To handle tasks associated with flight safety and the safeguarding of payloads, the control systems of Energiya and Buran are assigned the task of navigation and control of motion in the event of a malfunction in the carrier's engines. One of three possible flight variants are automatically chosen: the standard variation, with entry into a nominal artificial earth satellite orbit; the one-orbit variation if the carrier malfunctions occur in the final stages of the injection segment; and the maneuver involving the return of Buran to an airfield near the launch complex in the event of carrier malfunctions in the early stages of the injection segment.

Represent yet another of the most complex of Buran's systems is its combined propulsion system. Pointing to the complexity of this system is the number itself of power plants that make up the system: 48 motors representing three thrust scales. The two most powerful of the motors are designed to get the craft into orbit and to perform orbital maneuvering and braking during exit from orbit; 38 motors are used for control of motion relative to center of mass; and the other eight are used for precision maneuvers.

No less important a system of the orbital craft is the radio-engineering complex, which has capabilities for exchanging all sorts of flight information with the Flight Control Center. That complex also required a good many ground tests, in which particular attention was devoted to perfecting the communications between Buran and the Center through a relay satellite in geostationary orbit. The communications channel with the craft through that satellite has much greater capabilities than through ground or marine tracking stations.

The development of the automatic equipment, as well as the perfecting of Buran's automated descent and landing at an airfield, has a special place in the flight preparations. The complexity of the task stems from the fact that the descent trajectory of a reusable orbital craft in the atmosphere is roughly twice as long as the corresponding flight segment of a nonreusable craft, and the accuracy needed for the final landing approach is greater by more than three orders of magnitude. In addition, Buran's landing is done in an "engine-less" mode, which means that it must be reliably performed on the first (and only) approach.

The flight along the descent path is supported independently by the craft's control system to an altitude of

about 40 kilometers; it is then corrected first by electronic rangefinding beacons and then by electronic azimuth-elevation beacons. Above an altitude of roughly 90 kilometers, Buran's attitude control is effected by control jets only; between 90 and 20 kilometers, through the joint operation of control jets and aerodynamic elements; below 20 kilometers, with aerodynamic control elements only. Stability and controllability of the craft are maintained in the leg of the flight in the atmosphere within a range of speeds that extends from hypersonic (more than Mach 20) to Buran's touchdown speed of 300-340 km/h.

All those features of the reusable craft's descent—highly accurate landing on first approach, flight and operation of control elements in an unusually wide range of speeds, ground correction of on-board control system—forced the developers of the landing control system to perform an extremely voluminous amount of pre-full-scale testing, some of which was on numerous flying laboratories. Aerodynamic characteristics, as well as controllability at hypersonic speeds, were checked on geometrically similar models of Buran that were taken to suborbital trajectories by standard boosters. The subsonic control system with automated landing was checked and the rangefinding and beacon radar systems perfected with specially fitted flying laboratories based on the Tu-154 and Tu-134 airplanes.

The ground-based telemetry, television, and telephone reception facilities located in the vicinity of the landing airfield, together with the radar equipment for tracking and vectoring, were perfected through the use of flights of a MiG-25 fighter that was specially fitted for such purposes and was subsequently used as a chase plane and for video observation. The trajectory data from the radar facilities were processed on special minicomputers at the airfield, were displayed at the working positions of the personnel of the regional landing control group, and were relayed in digital form to the Flight Control Center near Moscow for identical display in real time.

The flight tracking radar facilities with processing and display of data and the rangefinding and beacon systems with the on-board transponder gear for correcting the independent control system were developed and perfected as a single electronic navigation and landing complex. Finally, all the on-board and ground-based systems of the orbital craft that involved subsonic speeds and the automated landing were perfected and checked on a prototype of Buran that was equipped with additional engines that enabled independent take-off from the ground. In all, nearly 150 automated landings were made with flying laboratories and the prototype before Buran flew in space. The future pilots of the reusable orbital craft flew the flying laboratories and the prototype.

In spite of the extensive on-board automation, Buran was linked by all the data and command links with the Flight Control Center in Kaliningrad below Moscow even during its first, brief flight.

The difficulties that had arisen and the brief duration of the flight operations required that the Flight Control Center have a higher level of automation for processing and transmitting data. The volume of the telemetry data transmitted from the craft (on-board computer complex data makes up more than half of it) had nearly doubled by comparison with that coming from the Mir-Kvant-Soyuz complex. For the first time in this country, trajectory data from a reusable spacecraft was being processes in a mode that was near real-time. Unlike previous flights, the transmission of command data was being done via intercomputer data exchange.

By the time the flight tests of Buran began, a special complex was in operation in the Flight Control Center with a new main control room and with space for support groups. The power of the Flight Control Center's computer and data-processing system was substantially increased with the installation of a fourth-generation PS-2000 computer, a VS-2, and an advanced terminal system for interaction with and use of personal computers. The overall capacity of the computer and data-processing system grew to 50 million operations per second, and the newly developed flight-control software contained nearly 2 million commands.

During Buran's first flight, the ground-based control complex, of which the Flight Control Center is the brain center, included six ground tracking stations, four floating stations (two ships in the Pacific and two in the Atlantic), and a communications and data transmission system that linked all the tracking stations with the Flight Control Center. Enlisted for support of the Buran flight were three geostationary relay satellites and a group of several satellites in highly elliptical orbits.

The experience that had been gained with long-term orbital stations and nonreusable craft pointed to the need for joint development, as well as testing, of on-board and ground-based flight control equipment. During the preparations for the flight and during the flight itself, this idea was embodied in their functional union within the framework of the automated flight control system. The control personnel at the Flight Control Center and the specialists at the tracking stations, the test-area measurement complex, and the landing complex made painstaking preparations for the first launch of the reusable craft. During the final, nearly four-month-long stage of the preparations, more than 10 combined practice runs were performed that included all the facilities of the Flight Control Center, the tracking stations, the test-area and landing complexes, as well as the ground-based simulation rigs, the flying laboratories, and the actual craft. During the practice runs, all the flight operations were worked out, with simulation of possible nonroutine situations.

The main mission of the first flight of the reusable space system was to continue the in-flight debugging of the versatile Energiya launch vehicle and to check the functioning of the structure and all the on-board systems of the Buran craft during the most stressful legs of the

flight—during injection and during the exit from orbit—with a minimal amount of time spent in the orbital leg. For that reason, the first pilotless flight of Buran was planned to be brief—two orbits around the globe, or 206 minutes of flight, beginning with lift-off from the launch pad and ending with the halt of the craft on the landing strip of the airfield.

But it turned out that the first launch attempt, on 29 October, was unsuccessful. Because of technical malfunctions, the automatic control system stopped the countdown 51 seconds (!) before the scheduled launch time. So all the equipment, as well as the services for prepping and supporting the flight, had gone through yet one more final general practice run carried out, it's true, at a rather high price. After all, the technology for repeating a launch postponed so close to start calls for dumping the fuel from the launch vehicle and the craft, with a subsequent 10-15-day preparation for a new fueling. In addition, the problem that arose had to be corrected and the work checked.

On 15 November 1988, despite a worsening of the weather, the State Commission approved the new launch time. This time, the whole sequence of prelaunch preparations went smoothly. At exactly 0600 hours, Moscow time, the space complex—the versatile Energiya launch vehicle and the reusable Buran orbital craft—lifted off from the launch pad, and in a matter of moments, the blinding tongue of flame departed into the dense cloud cover suspended above the spaceport.

The eight minutes of the injection leg dragged on surprisingly long. Finally, at 0608:03, Buran began its first independent spaceflight.

A specific feature of the ballistics of the flight of the Energiya-Buran complex is that after the launch vehicle finishes its work, the complex is about 150 kilometers above the surface of the Earth. For that reason, the Buran craft must use its own power to reach its working orbit.

Two maneuvers were performed in the first 40 minutes for the purpose of achieving the orbit. The parameters of those maneuvers (magnitude, direction, and moment of generated momentum of the propulsion system) were automatically calculated by Buran's on-board computer complex on the basis of the loaded flight specifications and the actual parameters of motion at the moment of separation from the launch vehicle.

The first maneuver was done while the craft was within the horizon of the ground tracking stations; the second, above the Pacific Ocean. An extraordinarily long path was used to transmit the telemetry associated with the second maneuver. Here are its components: Buran—floating tracking station aboard a ship in the Pacific—stationary communications satellite—Orbita relay station in Petropavlovsk-Kamchatskiy—communications satellite in highly elliptical orbit—relay point near Moscow—Flight Control Center. The length of the entire path was more than 120,000 kilometers.

The report of the ballistics experts soon followed: after performing the maneuvers, the craft had entered almost the exact orbit that had been calculated, with minimum and maximum altitudes of 255 kilometers and 265 kilometers, respectively.

After the maneuvers, Buran flew in an orbital attitude that put its left wing toward the Earth, for the purpose of observing the heat conditions. Telemetry, plus the "picture" produced by the on-board television camera located along the longitudinal axis of the craft, just behind the cabin window, was used to see to it that the proper attitude was maintained. All the commands issued by the Flight Control Center to control Buran's telemetry and television systems were carried out.

Then an important orbital operation was performed—the reloading of the on-line storage of the on-board computer complex for operation during the descent leg, plus the transfer of fuel from the nose tanks to the aft tanks to ensure a landing center-of-gravity position. Unexpectedly, at one crucial moment, there was an interruption in the telemetry transmission via a stationary communications satellite. That "shook up" the working rhythm of the Flight Control Center somewhat; but communications with the craft were reestablished after a few minutes, and we were relieved when we saw that the flight was continuing normally.

In all honesty, we note that there were some problems in the operation of certain on-board and ground system during the first test spaceflight of Buran. Not one of them, however, was major, nor did they affect the execution of the flight tasks on the whole.

Just an hour and a half of flight had gone by, and the on-board computer complex had already calculated the parameters of the braking maneuver for exit from orbit and reported them to the Flight Control Center. At 0820 hours, having developed the specified velocity, the engine was shut off, and the orbital craft began its descent. A half an hour later, it "engaged" the atmosphere, and at 0853 hours, at an altitude of 90 kilometers, communications with the craft were interrupted, because of plasma formations.

Buran's passage through the fiery plasma, by the way, lasts more than three times longer than does that of a descending nonreusable craft like Soyuz; by design, it lasts 16-19 minutes. The readers can understand our nervousness. Those minutes of flight sans communications, in conditions of the highest thermal loading, are no easier to endure than is the anticipation at launch. And then finally, at 0911 hours, when the craft was already down to an altitude of about 50 kilometers, the reports rang out: "Telemetry being received!" and "Detection by landing radars!" and "On-board systems operating normally!" At that moment, Buran was about 500 kilometers from the landing strip, and its speed—even though it had slowed—was still about 10 times that of the speed of sound.

Just a little more than 10 minutes remained before landing. The speed of the craft continued to rapidly slow in the atmosphere. Buran's motion was adhering strictly to the predetermined descent trajectory. On the Flight Control Center's control displays, Buran moved gradually toward the landing strip of the airfield almost right down the center of the allowed return corridor. At an altitude of about seven kilometers, an MiG-25 chase plane approached Buran. Thanks to the television camera it was outfitted with, we saw a television image of the orbital craft and were delighted: it's in one piece, undamaged, as if it hadn't even passed through the thorns of space.

Then began the final prelanding maneuvering and, at an altitude of four kilometers, the entry into the glidepath. The television cameras at the airfield began to transmit images to the Flight Control Center. A minute later, and the landing gear come down; and then, at 0924:42, the smooth touchdown on the landing strip. Such an incredibly beautiful, accurate, elegant landing by an 80-ton machine! It was just hard to believe that there was no crew in the cabin. We had been working toward that moment for more than 10 years, and now the first automated flight of the Buran reusable orbital craft was successfully completed. The world's first extremely accurate pilotless landing on an airstrip had been done.

It's hard to convey what happened at that moment in the Control Center room. Adults, people who were serious—even gaunt, almost gloomy—in the final days before the launch, specialists of all kinds, engineers, candidates and doctors of science, jumped up from their consoles and hugged each other and shouted "Hurrah!" Such genuine, universal rejoicing has perhaps not been seen for many years in flight control operations—probably not since Gagarin's flight.

But the emotions still had to be restrained. For another 10 minutes after the craft had stopped on the airstrip, the Flight Control Center had to see that the on-board systems were brought back to the initial state, and then that they were turned off. At the request of the postflight service group, we issued the final command to the craft from the Flight Control Center via communications satellite. The current to the Buran systems was cut off. That was it. We finally got the long-awaited chance to catch our breath.

Today we can state with confidence that more Buran launches lie ahead, as does the lengthening of its stay in orbit, and the transition to piloted flights.

What conclusion is to be drawn? The work involving the creation of the reusable Energiya-Buran system has facilitated the mutual enrichment of specialists of many sectors of the national economy, including those in civil aviation, with state-of-the-art experience in the development of space and aviation equipment; it has facilitated the creation of equipment for all-weather automated landing of aircraft, the development of advanced simulation and test rigs, and the improvement of computer hardware. A fundamentally new space transport facility has been produced. An important factor associated with the development and flight testing of the reusable system is the acquisition of invaluable experience in the organization of operations involving intricate cooperation among its participants.

All that represents the contribution that Energiya and Buran have already made today to the general growth and progress of our country's science and technology.

The Space Shuttle and Buran: Similarities and Differences

18660170 Riga NAUKA I TEKHNIKA in Russian No 4 Apr 89 pp 12-13

[Article by Candidate of Technical Sciences Yakov Gaukhman. First paragraph is introductory paragraph in source.]

[Text] **Looking at pictures of the American space shuttle and our Buran, some have noted with annoyance, "They're so similar, you can't tell them apart! Couldn't they think of anything new?"**

That impression is based on visible similarity. The outer form of the vehicles is dictated by the laws of aerodynamics, the conditions of flight from speeds near zero (during take off and upon stopping after the landing run) to orbital speeds (28,000 kilometers per hour), and a very wide range of flight altitudes—from zero to almost 500 kilometers—with corresponding changes in density and ambient temperature.

The West European Hermes vehicle looks the same.

These vehicles have an airplane configuration without a horizontal tail assembly, with a strong tail fin; a low, double-sweptback delta wing; and aerodynamic controls typical of an airplane: elevons, control rudder, and body flap. The wing, which has a blunt leading edge, is relatively thick, and the streamlined nose of the fuselage is also blunted. The wings are mounted flush with the bottom of the fuselage, and the side walls of the fuselage are straight. Buran is 36.4 meters long, the wingspan is 24 meters, the height on the tarmac is 16.5 meters, and the wing area is 250 sq. meters. The cargo section is the size of a railroad car, and, as with the American space shuttle, a 30-ton cargo can be placed in it—for example, the base unit of the Mir station or the Kvant module. The launch mass of the spacecraft is 105 tons. The hull of the spacecraft is not hermetically sealed and consists of three sections—the forward, middle (payload), and aft sections. The forward section is a sealed, all-welded cabin of more than 70 cubic meters, and it holds the crew and most of the equipment.

The aft section holds the propulsion unit for orbital maneuvering and the fuel, with an additional two bands of small control (vernier) engines whose nozzles control

the spacecraft in the rarified layers of the atmosphere. All of the engines are supplied by kerosene and liquid oxygen from common tanks. The total fuel supply is about 14 tons.

The main parameters of the American space shuttle are about the same.

Ensuring the soundness of the spacecraft is an extremely complex task, because of the extremely severe operating conditions: a very intense vibrational and acoustic load from powerful rocket engines and from supersonic air flows during acceleration in the atmosphere. But the most complex loading is the heating during re-entry into the dense layers of the atmosphere, when temperatures reach the melting point of some metals. When the spacecraft descends sharply in the atmosphere (a low-angle descent increases the heating time of the structure), it is completely covered with red-hot plasma, whose temperature, in the most intense regions, reaches 1600°C.

The load-bearing structures of Buran make use of new high-temperature alloys of titanium, beryllium, boraluminum, and niobium, and various composite materials are used in the airfoils. But since the allowable temperature of the main structure cannot exceed 150°C, the entire outer surface of the vehicle is covered with special black heat-shielding ceramic tiles. There are about 39,000 tiles in all (the American shuttle has 36,000; ours were developed with a technology different from Japanese and American technology). The tiles are small, so that thermal expansion of the hull metal of the craft does not break the ceramic sheathing. The shielding must be reusable, light, durable, heat-resistant, chemically neutral to pure atmospheric plasma, and transparent to radio-frequency emissions. The main surface of Buran is covered with tiles (adhering with a special glue) that are based on thin fibers of pure quartz with an operating temperature of 1300°C. The most thermally stressed parts—the leading edges of the wing and the tail fin and the nose of the fuselage, which have operating temperatures of about 1600°C—are made of high-heat graphite material. The total mass of the heat shielding is about nine tons. The creation of the heat shielding entailed a number of experiments and the launch of four special research satellites—Cosmos-1374, Cosmos-1445, Cosmos-1517, and Cosmos-1614—on which the tile thermal shielding was tested.

The main purposes of the American space shuttle and Buran have historically been somewhat different. The Americans use their vehicle for the launch and return of objects—they have not yet created a newer, inexpensive single-use system. We, however, have a whole series of boosters for that. The purpose of Buran is to launch very expensive, uniquely equipped objects which require servicing by manipulators, robots, and skilled specialists and to return them to Earth.

At times it is extremely important to return to Earth research materials, information, and satellites which are defective or have finished with their work, especially those with nuclear power units, so as to avoid polluting the atmosphere and the surface of the Earth.

Here the similarity of the American shuttle and Buran vanishes.

The American space shuttle is just that—a shuttle, a single unit intended only to lift the spacecraft into orbit.

The first stage consists of solid-fuel boosters (or rockets) 36 meters in height and 6 meters in diameter. It was impossible to make them in a unitized construction, because of the conditions for providing combustion; so each booster consists of four units which are butted together hermetically. This type of booster has 1495 tons of thrust, but after the launch, shutting them off or at least slowing the process of combustion is impossible. (The Challenger catastrophe—a stream of flame broke through one of the sections—occurred precisely because of the impossibility of shutting off the booster or slowing the combustion).

After 130 seconds the solid fuel boosters are burned out and are jettisoned by parachute into the ocean, where they are recovered, repaired, and once again placed in service. (It turns out that the re-use of the solid-fuel boosters requires expensive work which virtually nullifies the savings.) Further acceleration and gains in altitude are achieved with the shuttle engines using a central tank of liquid hydrogen and oxygen. The tank is 47 meters tall, and after it expends its fuel it is jettisoned into the ocean. Maneuvering in orbit and braking are done using small fuel supplies on the spacecraft itself. The launch mass of the complex is 2047 tons, and thrust at launch is 3000 tons.

The Energiya-Buran system was constructed on completely different principles. The universal Energiya rocket-and-space system can deliver into space many large objects that are of varying purpose and design and have a mass of more than 100 tons, Buran being only one such object of external attachment. At present, Energiya is a unique launch vehicle. It can lift loads into orbit that are three times heavier than the capacity of the American shuttle system. The most powerful launch vehicle in the United States, the Saturn 5, was created in the sixties for moon flights. The three-stage version of the rocket has lifted up to 130 tons into orbit, and the two-stage version, about 100 tons. In the early seventies, production of this rocket was halted for a number of reasons, in particular, high cost. At present, the United States is using the Titan 4, which can lift a total load of 25 tons, and the shuttle system, which can lift 30 tons.

Our Proton booster can deliver 20 tons into orbit. The Delta 2 rocket that is being developed in the United states will, by the middle or even the late nineties, be able to deliver a 50-ton load!

Energiya was built with a parallel configuration of rocket stages and lateral disposition of the payload, which consists of unmanned vehicles of various sizes and piloted spacecraft.

Energiya is 60 meters high, with a maximum of 20 meters across.

The first stage consists of four cylindrical units, each 40 meters long and 4 meters in diameter. They are attached in pairs side by side to the second stage. Each unit has a four-chamber liquid-fuel rocket engine which uses liquid oxygen and kerosene and which has a thrust of 800 tons (the most powerful liquid-fuel engine in the world).

The second stage consists of a central unit 60 meters tall and 8 meters in diameter. This stage also has four engines, which have a thrust of 200 tons each and which use liquid oxygen and hydrogen. The launch mass is 2400 tons, and about 90 percent of this mass is fuel and oxidizer. The total thrust at liftoff is 3200 tons. The first-stage side units, once used, are separated from the rocket in pairs and fall into a specified region (in the future, it is expected that they will descend on parachutes so that they can be re-used).

The central unit, on a Buran launch, is separated from Buran after reaching an altitude of about 160 kilometers, and then it falls into the Pacific Ocean. If necessary, it can make a maneuver and deploy Buran so that Buran can land at Baykonur or at a standby airfield. Later, the engine of Buran itself engages, pulling and accelerating Buran for 45 minutes (the engine operates at intervals of 100 seconds) until it achieves the so-called standard orbit 230 kilometers high, at which it reaches an orbital velocity of 8 kilometers per second.

Eight tons of fuel is expended from the Buran tanks. If it used its full supply (14 tons) it could lift a 27-ton payload to an altitude of 450 kilometers.

If it becomes necessary to increase altitude to 800-1000 kilometers, Buran can be fitted with fuel tanks to hold another 14 tons of fuel. For other loads, the capabilities of Energiya are completely different.

In developing the rocket, "cryogenic effects" were taken into consideration by increasing the durability of the tanks, containers, and other units at very low temperatures, which makes it possible to use thinner metal walls.

When the tanks are filled at a temperature of minus 255°C, the height of the rocket decreases by tens of centimeters, which was also stipulated by the designers.

The American shuttle lands on the floor of a dry salt lake using a telescoping landing skid, and it can land in any direction. Buran lands on wheeled landing gear at a special airfield near Baykonur cosmodrome. The landing strip of the airfield is 4.5 kilometers long and 84 meters wide. Its concrete slab is 48 centimeters thick. Depending on the direction of the wind, Buran can land from the west or the east. There are several standby airfields in different parts of the Soviet Union. Braking parachutes are used while Buran makes its landing run.

In contrast to the American shuttle, which always flies with a crew, the first flight and landing of Buran was done completely automatically, which made quite an impression on all foreign specialists. The automated landing ensures successful landing under any weather conditions. The extremely complex system acquitted itself quite well. The operation was off by only one second, and the axis of the spacecraft deviated from the axis of the airstrip by 1.5 meters in all (at winds of up to 20 meters per second!).

In creating Buran, the basic principles of flight safety were observed, with multiple redundancy used in the most important systems for that purpose. Even if one of the rocket engines fails, the spacecraft is guaranteed to return to the landing strip.

The expenditures on the creation of the Energiya-Buran system are comparable to the cost of the American space shuttle program—the initial expenditures alone of the United States exceeded 10 billion dollars. But it the Energiya-Buran space complex and the Energiya rocket booster are expected to pay back the investment, not only by ensuring space flights over many years, but also by providing new technologies and about 30 new materials that will be used in different branches of industry. The glue used to attach the heat-resistant tiles to the surface of Buran is already being used. The engines and electrochemical generators which use ecologically clean fuel components (hydrogen-oxygen) and the heat-insulating materials which are used at temperatures of up to 1600°C are already finding wide application. The automated landing systems and new computer complexes, among other features, are extremely important.

Nonetheless, we should not forget that shuttle flights began in the United States in 1981, and four spacecraft were built: Columbia, Discovery, Challenger (which was lost in January 1986), and Atlantis. Our Buran made its first flight at the end of 1988.

There are a number of subjective and objective reasons for this. The objective reasons include the fact that the priority in our space program is with the Salyut and Mir type orbital stations (an analogous station will be created in the United States in the middle to late nineties). Among the subjective reasons, you have to include the well-known, long-standing resolution of then USSR Defense Minister Grechko with regard to the proposed project of a Soviet reusable spacecraft: "Another fantasy—it's time we got down to serious matters." The aviation community is convinced that if it hadn't been for that, our Buran would have gotten into orbit long ago.

Commentary on First Flight of Buran Shuttle

18660171 Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 89 pp 26-28 and back cover

[Article by Doctor of Technical Sciences V. Kravets, flight controller for Buran orbiter, and Deputy General Designer O. Babkov, under the rubric "Supporting Space Flights": "First Flight"]

[Text] The development of a reusable system and the subsequent preparation of Buran for flight were begun against a background of the continued development of orbital stations. This, naturally, created additional organizational and technical difficulties.

From the very beginning it was determined that the first experimental flight of our orbiter would be unmanned, for the safety of the crew. This is traditional for the Soviet space program. This required full automation of all dynamic operations, including steering on the landing strip of the airfield.

More than ten years went by before the flight. The tension on the day of the launch was intensified by the prior cancellation of the October 29 launch.

On November 15 the entire sequence of pre-launch preparations proceeded without incident. At exactly 0600 Moscow time, the Energiya booster rocket with the Buran orbiter lifted off from the launch pad and almost immediately entered the low ceiling of clouds.

The eight minutes of the orbital insertion segment of the flight dragged on surprising long. At 0608:03 Buran began its first independent flight...

A feature of the ballistic flight configuration of the Energiya-Buran complex is that the booster completes its work at 150 kilometers above the Earth's surface, and then Buran must use its own resources to insert itself into orbit. For that reason, in the first 40 minutes, two maneuvers are made to place the spacecraft into a working orbit with the following parameters: inclination 51.6°, altitude 260 kilometers. The parameters of these maneuvers (magnitude, direction, and moment of the generated thrust of the engines) are automatically calculated by the on-board computer complex on the basis of the established flight plan and the actual motion parameters at the moment Buran separates from the booster.

The first maneuver took place in the radio horizon of the ground tracking stations. The second took place over the Pacific Ocean. The transmission of telemetry for the second maneuver went from Buran to a floating tracking station in the Pacific Ocean to a stationary communications satellite to the Orbita relay station in Petropavlovsk-Kamchatskiy to a communications satellite in a highly elliptical orbit to a relay point near Moscow to the Flight Control Center. The length of this path is more than 120,000 kilometers!

After the maneuvers, to maintain its thermal performance, Buran flew in an orbital attitude with the left wing toward Earth. The proper orientation of the spacecraft was confirmed not only by telemetry but by the TV "picture" taken by an on-board camera mounted on the longitudinal axis of the spacecraft behind the cabin window. The command radio link operated accurately, carrying out all commands transmitted from the Flight Control Center to control the telemetry and television systems of Buran.

Then comes one of the final operations—the reloading of the on-line storage of the on-board computer complex for operation during the descent and the pumping of fuel from the forward tanks to the rear tanks to ensure a landing center-of-gravity position. And wouldn't you know it, it had to happen that at that very time there was a failure in the telemetry transmission.

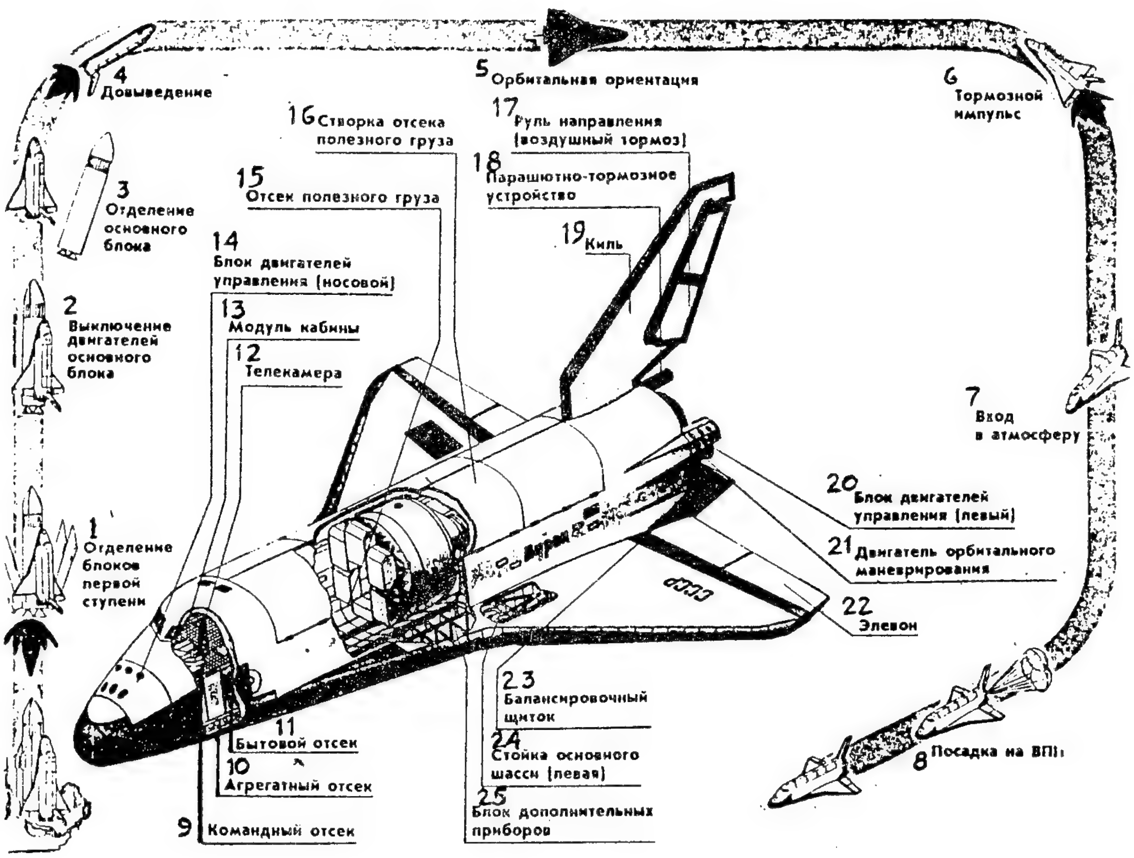
Jumping ahead a bit, let us note that during the first experimental flight of Buran, the operation of individual on-board systems was not without incident, but none of the problems were fundamental, that is, they did not affect the completion of the flight tasks as a whole.

An hour and a half of the flight passed, and the on-board computers had already calculated and reported to the Flight Control Center the parameters of the braking maneuver to descend from orbit. At 0820 the engine was turned on, it developed the requisite speed, and the spacecraft began its descent. In another half hour, the orbiter "engaged" the atmosphere, and at 0853, at an altitude of 90 kilometers, communications with the orbiter ceased because of the plasma formations. Buran's movement through the plasma lasted more than three times longer than that associated with the descent of a Soyuz-type nonreusable spacecraft, and it was calculated to be 16-19 minutes.

Finally, at 0911, when the spacecraft was at an altitude of 50 kilometers, the reports flew. "We are receiving telemetry!" "The landing radars have detected the spacecraft!" "Spacecraft systems are operating normally!" At that moment Buran was 550 kilometers from the landing strip, and even though its speed was decreasing, it was still travelling at ten times the speed of sound.

More than ten minutes were left until landing. The spacecraft lost speed quickly in the atmosphere. Buran was moving strictly according to the calculated descent trajectory, and on the control displays at Flight Control Center, the spacecraft blip was moving toward the landing strip virtually down the center of the allowable return corridor. At an altitude of about 7 kilometers a Mig-25 chase plane approached Buran, and we saw television pictures of the orbiter. It was intact and appeared to be undamaged.

The final pre-landing maneuvers began. At four kilometers it entered the glidepath. Images began to be transmitted to the Flight Control Center by airfield TV cameras. Another minute until the landing gear were deployed. And at 0924:42 Buran touched down on the landing strip. The landing of the 80-ton spacecraft was



Key: 1. First stage separation—2. Shutoff of core engine—3. Core separation—4. Final orbital insertion—5. Orbital orientation—6. Braking impulse—7. Entry into atmosphere—8. Landing on runway—9. Control compartment—10. Equipment section—11. Crew living compartment—12. TV camera—13. Cabin module—14. Control thrusters (forward)—15. Payload bay—16. Door of payload bay—17. Control rudder (air brake)—18. Braking parachute unit—19. Tail fin—20. Control engines (port side)—21. Orbital maneuvering engine—22. Elevon—23. Body flap—24. Main landing gear well (left)—25. Block of supplementary instruments

unusually beautiful, accurate, and exquisite. It was simply unbelievable that it was an unmanned flight.

The first automated flight of the Buran orbiter was completed, the world's first unmanned landing of an orbiter on the landing strip of an airfield.

And the things that were happening in the Flight Control Center! Adults who had been serious and even gloomy in the last days of flight preparation—engineers, candidates and doctors of science—were jumping up from their consoles, clapping their hands, shouting "Hurray!" and hugging each other. In the previous 20 years of flight control there had never been such genuine and complete rejoicing

But emotions had to be restrained. The Flight Control Center still had to control the return of on-board systems to their initial condition and their shutdown during the ten minutes after the spacecraft came to a stop on the landing strip of the airfield. At the request of the post-flight servicing group, we sent the last command from the Flight Control Center through the communication satellite to the spacecraft. The Buran systems were shut down. That was it! The entire program for the first experimental flight was completed.

All of the experience accumulated in the development of unmanned and piloted spacecraft with computers on board had been used to create the Buran control system. The practice of controlling the flight of orbital stations and nonreusable transport spacecraft shows that greater and greater amounts of tactical control tasks need to be transmitted to the on-board complex and crew of the spacecraft, leaving the Flight Control Center and ground personnel to carry out strategic planning, control in unforeseen situations, and the processing and interpretation of scientific and national-economy experiments and research.

Proceeding from these considerations, the control system of the reusable orbiter, which is constructed on the basis of a multi-machine on-board computer complex and special electronic equipment, was assigned the following functions: control of motion and operating conditions, diagnostics of on-board systems, automatic control of reserve units and on-board equipment systems, autonomous navigation, and automated planning of flight operations. These assignments were on a much broader scale than had been the case for spacecraft and space stations developed and used earlier.

On Buran, it is possible to load into the on-board computer complex the sequence of all necessary flight operations required for automated execution of the flight program and modifications for irregular situations while Buran is still on Earth preparing for launch. If necessary, the flight program of the spacecraft can also be changed from the Flight Control Center, using the command radio link.

Special functions are assigned to the control systems of the rocket and spacecraft with regard to safety and the maintenance of flight factors. If one of the liquid-fuel engines of the Energiya booster fails, the remaining power of the booster and spacecraft is redistributed optimally. If that were to happen, three flight variations are possible: regular flight, with entry into the calculated artificial Earth satellite orbit; a once-around flight (in booster failures during the late stages of the orbital insertion segment); and a maneuver to return Buran to the airfield near the launch complex (in booster failures in the early stages of the orbital insertion).

All that required the development of an unusually large amount of on-board software with use of high-level problem-oriented languages at the stage of control system development, as well as during ground and flight testing of the orbiter. Special, complex test rigs were created for ground testing the equipment and the on-board mathematics in regular operating modes and in a foreseeable variety of irregular situations. The complex of problems involved in the development and testing of on-board software was one of the central problems in creating the orbiter.

The broad capabilities of a control system with an on-board computer complex and the rather flexible on-board mathematics made it possible, even during final ground testing, and without changing equipment, to increase the reliability of the operation of individual systems on Buran and the forthcoming flight as a whole.

In the preparation of the spacecraft for launch there was an especially close interaction between the developers and the testers of the control system and the combined propulsion system of Buran, also one of the central and most complex systems of the spacecraft. The numbers tell the story of the complexity of the Buran engines: there are 48 engines, with three thrust levels. The two largest of these are intended for orbital insertion, orbital maneuvering, and braking during re-entry. There are 38 engines for the control of motion relative to the center of mass, and another 8 for precision movements.

Another one of the central systems of the orbiter is the radio complex, which makes it possible to exchange with the Flight Control Center all types of flight data: command, telemetry, navigational, television, and telephone data. This complex also required a large volume of ground testing. Special attention was paid to the testing of communications between Buran and the Flight Control Center through a relay satellite in geosynchronous orbit. Routing communications with the spacecraft through this type of satellite is much more versatile than is transmission through ground-based and ship-borne tracking stations.

The creation of equipment and the development of the automated re-entry and landing of Buran at the airfield occupied a special place in the preparation for flight. The complexity of this task is characterized by the fact that the descent path of a reusable orbiter in the atmosphere is about twice as long as for a nonreusable spacecraft, and the required landing accuracy is higher by a factor of three. Moreover, the landing is done without engines, that is, it must be carried out reliably on the first and only pass.

Flight along the descent path to 40 kilometers is effected independently by the spacecraft's control system. Below this altitude it is corrected first by electronic range-finder beacons, then by electronic azimuth-elevation beacon. The attitude control of Buran To an altitude of about 90 kilometers, Buran's attitude control is effected with jet engines; between 90 and 20 kilometers, with jet engines and aerodynamic elements; and below 20 kilometers, with aerodynamic control elements alone. In the atmospheric leg of the flight, the spacecraft must be stable and controllable from hypersonic speeds ($M>20$) to the landing speed of Buran on the landing strip of the airfield, 320-340 kilometers per hour.

All of these characteristics of the descent of a reusable spacecraft (the high landing accuracy and the requirement that it land on the first pass, the flight and the operation of control elements in an unusually wide range of speeds, the correction of on-board control systems from Earth) compelled the developers of the landing control system to carry out a large number of experimental pre-full-scale tests, including tests on many flying laboratories.

The testing of the aerodynamic characteristics and controllability at hypersonic speeds was done with models that were geometrically similar to Buran and were placed into suborbital trajectories using standard boosters. The operation of the control system at subsonic speeds was tested with the use of specially equipped flying laboratories based on Tu-154 and Tu-134 airplanes.

Ground-based equipment located in the region of the landing airfield and used for receiving telemetry, television, and telephone data, together with radar tracking and vectoring facilities, were tested during the flights of

a specially equipped Mig-25, which was used during the descent of Buran for television observation and as a chase plane. The trajectory data from radar was processed on special minicomputers at the airfield and was displayed at the workstations of the regional landing control group personnel; it was relayed in digital form to the Flight Control Center, for identical display in real time.

Radar flight-tracking equipment with information processing and display, the range-finding and beacon systems with on-board transponder equipment for correcting the autonomous control system were created and perfected as a single electronic navigational and landing complex.

All of the on-board and ground-based systems that support the flight of the orbiter at subsonic speeds in the automated landing were perfected and tested on a prototype of Buran that was equipped with additional engines for independent take-off from an airfield. A total of about 150 automated landings were carried out on flying laboratories and the prototype before the flight of Buran. Flights on the flying laboratories and the prototype were conducted by the pilots who would be the future pilots of the reusable orbiter.

Despite the extensive on-board automation of flight operations, even during the short first flight, the orbiter was linked with Earth by data and command links. The Flight Control Center exchanges all types of flight data with Buran: telemetry, navigational, command, television data, and in the future, for manned flights, telephone information.

The complexity that had evolved and the speed of flight operations required a higher level of automation of data processing and transmission at the Flight Control Center. The volume of telemetry data transmitted from the spacecraft (more than half of which consists of on-board computer data) was nearly double that of the Mir-Kvant-Soyuz flying complex. The exchange of command and program data with the spacecraft for the first flight was limited, but, in contrast to that of earlier employed spacecraft with on-board computers, it was carried out between computers, that is, between the data-processing and computer complex at the Flight Control Center and the on-board computer complex of Buran. For the first time in the Soviet Union, the processing of trajectory data from the reusable spacecraft was carried out in near-real time.

All of these features of data processing and transmission necessitated considerable modification of the facilities at the Flight Control Center, an expansion of the capacity of ground-based software, and a higher level of automation of preparation of initial data for its development.

By the time preparations for flight testing of Buran began, a special complex was built and equipped at the Flight Control Center, with a new main control room and space for support groups. The power of the data-processing and computer complex of the Flight Control Center was increased considerably with the introduction of fourth-generation PS-2000 and VS-2 computers, an advanced terminal system for user interaction and the use of personal computers. The total capacity of the data-processing and computer complex of the Flight Control Center increased to 50 million operations per second. The volume of the newly developed software for flight control numbered about two million commands.

The ground-based control complex, the nerve center of which is the Flight Control Center, included during the first flight of Buran six ground-based tracking stations (in Yevpatoriya, Moscow, Dzhusaly, Ulan-Ude, Ussuriysk, Petropavlovsk-Kamchatskiy), four floating stations (two ships in the Pacific Ocean and two ships in the Atlantic Ocean) and the communications and data-transmission system that links the tracking stations with the Flight Control Center. This system in turn consisted of a network of ground-based and satellite wideband and telephone communications links. Three relay satellites in geosynchronous orbits and a grouping of several satellites in highly elliptical orbits were used for the Buran flight.

The experience garnered with long-term orbital stations and nonreusable spacecraft showed that joint development and testing of on-board and ground-based flight control facilities was necessary. During the preparations and the flight of Buran, this idea was embodied in their functional unification and testing within the framework of an automated flight control system.

The flight control personnel at the Flight Control Center carefully prepared for the first launch of Buran. In the final stage of preparation, in the four months before the flight, about ten comprehensive practice runs were carried out involving all equipment that had been put into operations at the Flight Control Center, the tracking stations, the test area complex, and the landing complex. During these practice runs, all of the flight operations were performed over and over again, with simulations of possible irregular situations.

The goal of the first flight of the reusable system was to continue the flight testing of the Energiya universal booster and to check the performance of the structure and all on-board systems of the Buran spacecraft. Thus, the first unmanned flight of Buran was planned to be short, two orbital passes, or 206 minutes of flight.

Work on the reusable Energiya-Buran system and its successful first testing contributed to the mutual enrichment of current experience in the development of space and aviation technology, to the creation of all-weather automated landing equipment, to the development of powerful experimental and testing bases, to the improvement and application of computer technology, and to the acquisition of experience in the development and debugging of large volumes of real-time software. An important aspect of the development of the reusable system

was the acquisition of invaluable experience in organizing work in the development of an automated flight control system, with intricate cooperation among the participants.

All of this is today's contribution of Energiya and Buran to the overall development and progress of our science and technology.

Interview with G. I. Severin, Chief Designer of Aerospace Ejection Seats, EVA Equipment

18660186 Moscow PRAVDA in Russian 26 Jun 89 p 4

[Interview by PRAVDA correspondent with G. I. Severin, general designer of life-support and rescue systems, hero of socialist labor: "To Save Man: A Conversation With the General Designer of Life-Support and Rescue Systems, Hero of Socialist Labor G. I. Severin"; first two paragraphs are introductory paragraphs in source]

[Text] **The new MIG-29 jet fighter suffered an accident during a flight demonstration at an airshow near Paris. Two seconds before the plane crashed into the ground and exploded, the test pilot, Anatoliy Kvochur, used his ejection device. The flyer is alive and unharmed. The world's leading specialists in aviation equipment who were looking on as this happened acknowledged the self-control and skill of the pilot, but also noted that his life was saved by a standardized ejection seat which, in all its characteristics, surpasses the best western models.**

The ejection seat is one of many developments of a one-of-a-kind enterprise—the Zvezda factory. It was only yesterday that all of the factory's activity was hidden by the thick veil of absolute secrecy.

The cosmonaut maneuvering unit (CMU) used by a cosmonaut to maneuver in open space reminds one of a rather compact cupboard with two arm-grips that extend forward and on which there are control panels. The cosmonaut floats out of the airlock, fastens this cupboard to his back (or fastens himself to "umk"—it's hard to tell) ["umk" is the colloquial Russian acronym for the CMU, based on the Russian abbreviation UMK], and then, let's go—all you have to do is flip switches.

After I went through a short training period on a special test stand in one of the plant's buildings, the lead designer of this "stellar sweeper," V. A. Frolov, suggested that I try out his creation in open space. "Do you think I can do it OK?" "The main thing," the chief designer reassured me, "is not to lose sight of the orbital station, and don't get fidgety. Besides, the CMU is connected to the station by a durable tether, so you won't fly away too far."

So look, it would be a sin to turn down such an opportunity. Only a few cosmonauts have flown "umk," and of my colleagues of the pen, no one yet has been awarded this pleasure. Well, here goes!

First, they asked me to undress and put on thin wool underwear. They led me to a spacesuit that was suspended from a beam by a steel cable. I climbed into it feet first, as if through an air vent into a small booth. To tell the truth, for want of practice, it was tough to get settled, and I could hardly move my arms and legs: this was normal. And then a door with a life-support-system pack suspended from it was firmly shut on my back. It became quiet and a little scary. The helmet glass began to fog up a little. "Don't worry," said a voice in the earphones, "we'll pressurize you now."

Space is blacker than the most pitch-dark night. The silver structures of the orbital station's mooring unit, to which I was fastened, seemed familiar and warm. "Go ahead," encouraged a voice in the earphones, "cast off." My gloved hands rested on the grips with the panels. A small movement of the fingers, and the airlock section slowly moved back. I'm off. Nothing is comparable to this sensation of free flight. Trying not to go too far from the station, I begin my first trip in open space.

[Beginning of interview]

Gay Ilich, tell us what made it necessary to create such a "space motorcycle"?

Severin: Let me begin by saying we started work on the first version of the CMU under S. P. Korolev, in the mid-sixties. That design actually reminded one of a motor scooter: the cosmonaut literally had to fly atop it. Unfortunately, we were unable, for a number of reasons, to test it in space.

Then many specialists—even well-recognized specialists—began to state that there was really nothing for man to do in open space and that all his his work could be done by robots. Life itself changed tHe sceptics' mind—especially the episodes during space flights when members of the crew had to go outside to perform in-flight repair of certain units and assemblies. And when the question of building large structures in orbit came up, the idea of a CMU was rehabilitated once and for all. Incidentally, the Americans made a similar device as far back as in the early eighties.

Up until recently, your name was never mentioned in the press, you were a "secret" designer, and your enterprise was surrounded by a high level of secrecy. Now, times have changed. In fact, they have changed so much that you allow your western colleagues to visit your "firm." But even now, few know much about you, even though you are the country's leading specialist on the creation of aviation and space life-support and rescue systems. So for a start, tell us a little about yourself.

Severin: I was born in 1926 in Chudov, not far from Leningrad. My father, who was from a very poor family, received training as an agronomist. My mother studied for a time to be a doctor. When the war broke out, my brother, who was in his tenth year of schooling, volunteered for the army. He was killed on 23 February 1943, in the Orlovsk-Kursk sector.

In 1942 I read an announcement that the Moscow Aviation Institute, which had been evacuated to Alma-Ata, was recruiting for a production section. I recall that I wanted to build airplanes. After becoming a student there, I returned to Moscow with the Moscow Aviation Institute. In 1947 I had completed five courses. I dreamed of becoming a test pilot, so I went to work at the Flight Testing Institute. In those same years I was very active in sports, but they wouldn't take me into the test pilot school without a diploma for graduation from the flying club. What could I do? I entered graduate school and the flying club, which was in Tayninka, at the same time. I would rise at four in the morning, get on a motorcycle, ride 70 kilometers from Zhukovsk to Tayninka, and fly gliders. By nine, I was back at the Flight Testing Institute. I worked as an engineer and participated in the testing. When I was 29, I defended my candidate's dissertation, and in 1955 I was invited to pilot's school. But I had already been thinking: should I study to be a test pilot, or remain an engineer? I decided it was too late to get into flying.

At the Flight Testing Institute I became the head of a section and directed a research laboratory. I was awarded the Lenin Prize.

On 25 January 1964, the minister called me and offered me the post of chief designer and the director in charge of the Zvezd factory. I told him I would think about it. I hadn't even reached the Flight Testing Institute when the minister called again. He said that he had already signed the order for my appointment.

Tell me, do you believe in luck? Your being made general designer—was it a coincidence, or the sum of single-minded efforts?

Severin: Intellectually, I don't believe in luck. Luck gives man a chance, but it's more important that he know how to use it. I think that it was mainly striving for a goal. In my childhood, after an illness, I was categorically forbidden to engage in sports. My heart was very bad. My brother was a great athlete, and I tried to keep up with him. I loved skiing, gymnastics, and mountaineering. I started to train, and in a few years, my heart returned to normal. I gained the title of national champion in alpine skiing, was fit for flight work without restrictions. Romanov, who was director of the sports committee then, many times said, "Give up work; go on a sports stipend." Expressed in today's language, he was bidding me to become a professional. "No, Nikolay, Nikolayevich," I answered, "I will not give up work; skiing will remain my hobby."

Luck? If luck has favored me, it has only been to give the opportunity to prove myself. I wnet to work at the Flight Testing Institute, and when the traditional methods of testing exhausted themselves, we developed new methods, and I was lead engineer. During the war in Korea there were a number of accidents when pilots ejected. A strong division was created to study and create rescue systems. The head of this division was V. V. Utkin, and he brought me there. So, since the fifties I have been working on my favorite project.

Luck gave me the opportunity to meet and work with many outstanding designers: S. P. Korolev, S. A. Lavochkin, A. I. Mikoyan, A. N. Tupolev, P. O. Sukhoy. I had gotten to known Sergey Pavlovich Korolev before the Gagarin launch, while working on a cosmonaut seat. I began to go to him with various ideas. For example, I went to him with the idea of soft-landing engines. Everybody was against it—they said it couldn't be done that way. But Korolev agreed that it should be tested. I quickly found out that he listened to young people. Korolev's support gave me much encouragement.

Over the years, any previously unpublished information, any new fact about Korolev has attracted great interest. Everything is important, and everything must be preserved. Thus, I would like to ask you to talk in more detail about your encounters with Sergey Pavlovich.

Severin: In the middle of 1964, when I was already chief designer, I went to him and suggested that a walk in open space be carried out. This required an airlock and a spacesuit be developed. Korolev supported the idea. The EVA was done on 18 March 1965, that is, nine months after our discussion.

Unbelievable. Can that be possible?

Severin: Yes, the story is worth telling. When we met with Korolev, we knew that the Americans, after putting their Gemini into orbit, wanted to open a "skylight" in space and simply sit for a while in an open cabin. It was impossible for us to open a hatch: it was secured with nuts. Then we proposed to modify the craft, equipping it with an inflatable airlock. Sergey Pavlovich approved the idea and asked "Can you do it quickly?" I said, "It could be done, but I don't have the lathes to machine frames." These are the basic load-bearing elements of the lock, which are attached to the spacecraft. Korolev quickly called his chief engineer and said, "From now on, there is another commander aside from me at our enterprise, and that's Severin. You should carry out his orders faster than mine." And the engineer tried to do just that. He said to me, "I'll do everything for you—just don't complain to Sergey Pavlovich." In nine months we developed the project, manufactured several airlocks, spacesuits, and life-support systems, and tested them. A miracle? Yes, now its hard to believe. And you can imagine what dramas unfolded and what tempers boiled!

We did the testing at our plant in the decompression chamber and made all the modifications. But before sending a man into space, we agreed to an unmanned flight. The goal was to send a spacecraft into orbit, deploy the airlock, inflate its load-bearing air frames, and then open the hatch—that is, automatically carry out the airlock cycle and measure all parameters. A spacesuit was placed in the airlock near the exit hatch. It was to be automatically inflated, sealed, and so on. The craft was to make several orbits, testing in sun and shadow in various modes.

Not long before the manned launch we sent this spacecraft into space. It must be said that the Americans planned to do their EVA in three months and had announced it beforehand. So we felt very rushed. We were hurrying and were nervous. And then an extraordinary thing happened. The unmanned spacecraft entered orbit and...disappeared. We tracked it to Kamchatka, and then it vanished into thin air.

What happened? Unmanned spacecraft were equipped with a self-destruct device in case of an unforeseen landing in foreign waters or territory. The flight plan called for the spacecraft to pass over eastern control points, from which the program on the spacecraft would be activated. The system to switch the program on was set up in such a manner that commands had to be sent sequentially from two different points. But officers of the radio command link each accidentally gave their commands at the same exact second. This is unbelievable, but it is a fact. At the same instant! And so two different commands with the code to turn on the program combined and gave the command to self-destruct. This was unprecedented in history. The craft exploded.

After that there was another accident. Parallel work was being done to develop an emergency firing of the airlock. After all, if the airlock wasn't blown off during landing, then a normal descent of the spacecraft would be impossible. After the descent craft was made, we flew with Sergey Pavlovich to Feodosiya. There, the craft was dropped from a transport plane, to simulate blowing the lock, balancing the craft in landing mode, and triggering the parachute system. They dropped it. And can you imagine... the parachute system didn't open. The craft broke into pieces. An out-and-out fatal failure.

But that is not all. Something called the "action" airlock, which had been prepared for the flight, fell from the suspension when it was being installed on the craft, and it was smashed.

And the flight had already been scheduled for 18 March 1965.

Sergey Pavlovich was a yellowish-green all over. The program had clearly failed. He called me, as he often would, at night, midnight or so: "Are you asleep? Can you come over?"

Korolev lived in a cottage, and I lived not far away in a hotel. "Well, what should we do?" I asked for two or three days to analyze the problem.

The situation was really grave. Almost the entire testing program had been disrupted. Only part of it was completed in the unmanned flight: they had opened the airlock, depressurized, opened the hatch, the suit had filled, and the automatic system had worked. But all this occurred in seconds.

Using government communication links, I set up an exchange of opinions between the group at the plant and the group at the testing area. We analyzed everything. Again we checked the reliability of all the units. And we made the decision to go with the flight. I reported to Korolev: "Sergey Pavlovich, we're going ahead with it." You had to see him at that moment: his face was dead tired, but his eyes lit up, and he asked, "Are you saying this seriously, or naively?" "Seriously." Korolev asked for the test materials and questioned me for a long time about the details.

But we still had to get it through the State Commission. The chairman of the KGB appeared unexpectedly at Baykonur. He arrived at the testing area and came up to us at the engineering site, where we were preparing the airlock. I said that it was a passage. He climbed through the airlock himself.

It's possible that the KGB thought all of our accidents were the result of imperialist intrigue, I don't know. But they established very strict monitoring, which made us very nervous.

Then Keldysh showed up with Korolev, and they looked around. They politely listened to me again. The State Commission convened. The situation was very difficult.

The simplest thing for me, the chief designer, the one with his head on the block, would have been to say that another unmanned flight was needed. But this would have caused a delay of a year. We were certain of the reliability of our systems. In the end, they agreed with me.

The first space walk went flawlessly. It is true though that the flight did not go completely without incident: the automatic landing system failed. Belyayev and Leonov landed manually, missed the target, and landed in the taiga below Perm. For several hours, their fate was unknown. And then I saw tears falling from Sergey Pavlovich's eyes. For a long time there were no communications with the cosmonauts, nothing. Korolev was on edge.

The ascent into orbit went very well. Everything was going, as they say, according to plan, with the exception of some small details. For example, Leonov found it difficult to get back into the airlock. But we had provided for the transfer to be done at a lower suit pressure, which made mobility better. He took advantage of that, and everything after that went normally.

You ask if there was a risk. And if a risk was at all necessary. It was, I will say, necessary. One must know how to make a decision on the edge of technical risk. Better said, there should be a substantial, well-based confidence in success, plus intelligent risk.

Moreover, you'll never do anything outstanding if you follow a traditional path. You'll always lag behind. It was then that I became fully convinvced that one should always look for unusual solutions, even those that seem improbable or that look as if they can't be done. If you work right, if you mobilize scientists and designers, then you can achieve victory in this strategic direction.

And were there other encounters with Korolev? They spoke of his unbelievable inflexibility, both towards himself and others...

Severin: There was such an episode. At Baykonur, during the preparations for that ill-fated flight, I receive a telegram that my father is near death. A train left for Alma-Ata in the evening. I called Sergey Pavlovich and said, "I need to leave for a day or two." "What happened?" "My father is not well, and I may be of some help; if I don't go, I'll never forgive myself." "Well, go ahead." I hung up the phone, called for an M-20 car, and then phone rang again. It was Korolev: "I'm sending a Volga for you." He was the only one who had a Volga, a dark blue one, and it was the only one at the testing area. He said, "It will be faster." "I'm in a hurry, Sergey Pavlovich." He hangs up the phone, and in such situations it was useless to talk to him. I grabbed my brief case and was about to go out when the phone rang again. "What, Sergey Pavlovich?" "How are you getting to Alma-Ata?" "By train." "No. There's an AN-12 landing right now. I ordered them not to turn off the motors. Now get a move on, and it will take you to Alma-Ata." "Sergey Pavlovich, why should that plane race for me?" "That's none of your concern. I'll send an LI-2 for you tomorrow."

I arrived in Alma-Ata at about two in the morning. It was dark and icy. I quickly excused myself from the crew and turned to the airport building. Suddenly I heard a car coming up behind me, and someone asking for me. I go back. By the plane was a tall man in a military overcoat. "Are you Severin?" "Yes." "I'm the commander of the military district, and I've come to meet you." I was taken aback, "Thanks, but why?"

I went to the kolkhoz to my father. I found the doctors, and they did what they could to ease his pain. At noon I was at the airport again, and in two hours I was at Baykonur. I went to Korolev. "Thank you very much. But I don't understand, Sergey Pavlovich, why you arranged for a general to meet me. I could have taken a taxi and gotten to the kolkhoz." "What post do you hold?" Korolev frowned. "Chief designer." "Just remember this: a chief designer must work day and night, and not be distracted by anything. Generals should meet him and drive for him. That is all. Go."

I'd like to know, Gay Ilich, how is your life structured? Are there any rules or principles that you live by?

Severin: Yes, I have a few principles which I have worked out over the years. First, don't force your ideas on people. Let others working around you accept your ideas as their own. This makes it possible for people to work to their heart's content, and of their own accord. To simply administer means to get nothing worthwhile accomplished. Your idea should become the idea of the people carrying it out, no matter who they are—from deputy general to metal worker.

The second principle is to do good for people whenever possible. People constantly turn to the director with questions about work, about life. Good people come to you and antagonistic people come to you. And if you can, you should do everything possible to help each one.

The third principle is in working something out, to seek the best decisions and try to implement them, no matter how difficult that is. Sometimes people reproach me, saying, why lean over backwards, we've met the demands of the customer, even exceeded them, and you want to do even better. I answer them by telling them to imagine that their own son is flying in this contraption, it goes down in some accident, and he returns a cripple.

By the way, speaking of contraptions. It seems to me that it's time to talk about how the standardized ejection seat was developed.

Severin: But first I have to tell you why we developed it. At one point, each design bureau making jet planes designed its own seat. There were so many types, you couldn't count them. Unfortunately, it wasn't that way just for seats. Our aviation designers, for some reason, just didn't care to standardize. There were probably a hundred kinds of airplane wheels. If one put a 180-mm wheel on his plane, another ordered a 178-mm wheel or a 182-mm wheel. There were over a hundred types of tires. Each made his own tire.

We set a task for ourselves: to create a universal, standardized seat. We understood well that we could introduce it only if our seat was better than the others in all respects. In all respects! Only then would there be any hope that they would agree to our version. So we developed our version. It was smaller than the others, lighter, and better in all other respects. It could also be installed in any airplane. Testing showed the absolute advantages of our development. Absolute advantages! An act of the State Commission recommended the new seat for all types of airplanes. But then, no one rushed to part with the old designs.

Why not?

Severin: You see, first, there are so-called departmental interests which poison our life this way everywhere. Second,... well, more detail is needed for this second point.

During the state testing stage, we lost the test pilot Valentin Danilovich. There were two test pilots for the ejection system involved in this story—Oleg Khomutov and Valentin Danilovich. Both were former students of mine, excellent skydivers. Khomutov worked at the parachute institute then, and he did all the factory testing and completed several ejections. After that, the seat went for testing to the air force, where Danilovich worked.

That was a dark day. He ejected normally. I was flying nearby in a helicopter and saw that. But because of pilot error, Valentin landed in a bay. Not on the testing grounds, where all the rescue teams were ready, but in the water. He got tangled up in the parachute cords and choked. The cutter picked him up, and he was still alive,

but there were no respirators on board. Valentin died of asphyxiation. That was the first conclusion of the medical people at the civilian hospital.

However, the director of the air force institute didn't agree with that. A new version was proposed: in the process of ejecting, the test pilot broke his back and because of that, they said, he drowned. Right away a commission was formed and an act signed. I spoke out against it. I nearly had a stroke, a heart attack. Without going to the heart of the problem, people defended the honor of the uniform, and turned to out-and-out forgery. And the test pilot had already been buried.

Nonetheless, I was able to have the body exhumed. There was no fracture. Testing could continue. And then Khomutov ejected under the same conditions (at 1.5 times the speed of sound). He reported in the air by radio. He landed normally, and shortly after this, he was awarded the title Hero of the Soviet Union. That put a period after the whole thing.

Well, maybe not a period, but a comma. A paradoxical situation arose. The seat had undergone successful state testing, and it was confirmed that it had superlative characteristics, but...but not one firm, except the design bureau of Pavel Osipovich Sukhiy, rushed to take it. Something good can always come from misfortune. Yakovlev made a vertical take-off airplane for flying from the decks of ships. He installed his seat on it. I suggested ours. During take-off and landing (the most critical situations) it undoubtedly saved pilots. I showed our development to the command of navy aviation, and they supported us. What really convinced them was that our seat saved the pilot even at zero altitude. We demonstrated it, and it was put on Yakovlev's plane. After that, they began to put in others, too.

Now our seat is installed in almost all of the air force's planes. Over 300 ejections have already occurred in actual use. And almost all of the pilots were saved. We save 97 out of 100. Before, 82 of those who ejected were saved. It is also important that we save pilots with virtually no injury. And we return them to action.

What do you mean by ejecting at zero altitude? From the ground? To what height must the pilot eject from the cabin so that his parachute can open?

Severin We weren't ejecting test pilots from the ground, but then there were many such cases in real-life situations involving aircraft. They ejected at various points: when parked, during take-off, at landing, during the landing run. The pilot is shot up 70 meters, and the automatic system forcibly opens the parachute.

More difficult were the problems we, along with the specialists of A. S. Yakovlev's design bureau and the Flight Testing Institute, had to solve in developing systems for a vertical take-off aircraft. The reactions of the most able and trained pilot are inadequate for a timely ejection when there is an emergency at takeoff or landing. It was therefore decided to develop a system which automatically rescues the pilot without his knowledge, as soon as the situation becomes dangerous during take-off or landing. And this, the first system of its kind in the world, was developed.

At first the pilots didn't trust it. They said, "What is this—I'm an experienced pilot, and some device of yours is going to eject me? No, I'll do it myself." But we stood our ground. And in the end we obtained, I would say, a unique result. By comparison, the English, who have the same type of aircraft—the Harrier—but without an automatic ejection system, have lost 100 percent of their pilots in accidents at take-off and landing. Not one has been saved. We have saved all of ours. All of them! This is a fact. And now the pilots think that our seats with automatic ejection systems are their guardian angels.

And now, let's return to the question of why it was so difficult to introduce your developments? After all, we're not talking about some routine department, but about defense and space...

Severin: It could be that not all of the general designers believed in our collective or in a young chief designer. Standing my ground before the the commander-in-chief, before ministries, I proved that we, by introducing a standardized seat, would save millions of rubles. They would take many types of engines, parachute and oxygen systems, firing mechanisms, and so on, out of production. And we would make just one type. There would be one type of simulator everywhere. One type of equipment. Simpler. Cheaper. Safer. More reliable. But they didn't agree with me right away, no, it was far from right away.

Now it's easier to solve these problems. First, the authority of the "firm" has increased significantly, they deal with us. And it's a different time.

In the showroom of your enterprise are examples of what you have created over the years. All kinds of things! And in each unique design is an element of an original solution. It is a shame that this museum isn't yet accessible to the general public. Future engineers might take a lesson in creative exploration and in daring. Nevertheless, Gay Ilich, what, in your view, are the most important achievements of the plant?

Severin: On the whole, our main task is to make the use of aircraft and spacecraft more efficient. That is a general direction. It includes many aspects. To do everything to make the work of the pilot and cosmonaut efficient. To increase the capability to continue a mission. To rescue in emergencies. Plus, to increase the safety of civilian aviation flights, and ensure rescue in emergencies. We have helped paratroopers—now, using what we have developed, they can drop combat crews right in their own machines.

But one of our key achievements—possibly the most important—is that we have managed to create a collective of scientists, designers, experienced production personnel, experimenters, and testers that solves all the problems within the complex. There would seem to be no other enterprise like it in the world. After all, how do they develop, say, pilot life-support systems abroad? They take the ejection seat from one firm, the oxygen system of another, an anti-G suit or a partial-pressure suit from a third, a protective helmet from a fourth, and so on. We are the only ones in the world who do everything in one complex, all together. And since there are many individual elements that must be linked together in these systems, solving the problems all at once is of principal importance. We have a strong physiology division and a huge experimental base. In our work we proceed from man and his capabilities, which we study and verify ourselves. And we put together the entire complex on the basis of elements which work together well and are well tested. In sum, the integrated system which we create has very good specifications and is more compact and reliable than its foreign counterparts.

Over the years, we've had a whole galaxy of bright specialists spring up: V. I. Svershchey, N. I. Afanasenko, I. P. Abramov, I. A. Sokolovskiy, F. S. Timokhin, A. Yu. Stoklitskiy...

Gay Ilich, all that you have talked about and everything I've seen at the plant is, of course, impressive. But how can I not ask why is it that in real life, in emergency situations that come up from time to time, rescue equipment for our pilots, sailors, and soldiers doesn't work? And at times there is simply no rescue equipment. We are reminded of the recent fire on a submarine, and other accidents. What can we do to see that people who, by chance or because of the irresponsibility of others, find themselves in an emergency situation are saved?

Severin: You have touched on an extremely important problem. It can be solved only in complex. First, there must be improved means of emergency rescue that can save the lives of the crew and passengers in an emergency and, if necessary, help to quickly and safely evacuate a plane or other transport vehicle. They should include oxygen-supply units, high-altitude and protective equipment, fast-acting emergency exits, ejection seats, inflatable emergency ladders, and so on. Second, we need a means of quickly finding those who have suffered a disaster, plus the emergency supplies necessary for providing first-aid and ensuring survival, which is especially critical in difficult climatic and geographical conditions. And third, we need a well-organized, well-equipped, interdepartmental state search-and-rescue service with professionally trained personnel.

[End of interview]

Alas, I must acknowledge that my first flight in open space ended in confusion. I got carried away and lost sight of the station. With the impenetrable darkness all around me, I got worried and began to feverishly press all the switches and knobs one after another. In my earphones, they laughed: "Calm down, we'll help you now." In a few seconds I was hanging upside down, about twenty meters above the crew compartment. Not wanting to tempt fate any further, I went to the mooring.

This took place near Moscow, in one of the laboratories of the Zvezda plant. The realistic simulation of flight in open space was achieved in a special simulator with a system of television cameras and a computer. But the way, the hour is near when the CMU takes a man into space for real.

'Mriya'-'Buran' Transport Operation Described

PM2605142789 Moscow IZVESTIYA in Russian 24 May 89 Morning Edition p 6

[Special correspondent V. Belikov report: "'Buran's' Second Flight"]

[Excerpts] Moscow Oblast—A winged tandem—the "Mriya" An-225 freight aircraft with the "Buran" reusable spacecraft—has flown from Baykonur to Kiev.

This was, in point of fact, "Buran's" second flight since the automatically conducted test in orbit conducted 15 November last year. Its base was now to be transferred from the cosmodrome to one of Kiev's airfields, using the universal transport system specially created for this purpose—this is what the world's largest heavy freight aircraft, the An-225 designed by Hero of Socialist Labor P. Balabuyev, is called. [passage omitted]

How was the (as yet!) unique "Mriya"-"Buran" transport operation carried out?

A. Bulanenko, deputy general designer, speaking:

"We landed at an airfield near Baykonur 10 May. Some 30-40 minutes later we caught sight of 'Buran' in the distance, being towed in our direction. While it was approaching, we unloaded from 'Mriya's' fuselage some of the equipment and apparatus on board, which is used on test flights—these, as is known, are in full swing on the An-225. I will point out that in the future special dismountable assembled lifting equipment will be delivered to the loading site inside the aircraft.

"At the cosmodrome we used a powerful stationary system to install the spacecraft on the 'roof' of the aircraft. A comparatively small group of specialists coped with that operation and reliably docked 'Buran' with 'Mriya' in less than 2 working days. As early as the evening of 11 May we were able to carry out two test runs along the airfield's concrete strip. Naturally, the spacecraft is empty now: There is no one in the cockpit, the freight compartment is clear, and the fuel tanks have been drained of their contents. In order to prevent the head wind during the takeoff run and flight from deforming 'Buran's' empty tanks, a special pneumatic

system from the aircraft pumps preheated air into the orbital craft under pressure." [passage omitted]

On 23 May "Mriya" flew from Kiev to a test airfield in Moscow Oblast, carrying "Buran" on its upper mounting. Subsequently it is to go to the international aerospace show in Paris.

Television Shows 'Mriya-Buran' Flight Tests

LD0406220489 Moscow Television Service in Russian 1700 GMT 4 Jun 89

[From the "Vremya" newscast]

[Text] [Announcer] As we have already reported, the Mriya-Buran aviation transport system is undergoing flight tests. Our viewers are interested in the details of this operation. [Video shows Mriya, an AN-225 on the tarmac, being towed]

[S. Slipchenko] It is the first time that this work has been done. It was experimental, and this gives us the right to speak in greater detail about it, all the more so since the sight, believe me, was really gripping. It seemed that Mriya took a long time to reach the place where it was to be docked with Buran. There are only a few cranes which are able to unite these two systems.

The orbital craft hung in the air and showed its wounds, received during space flight. Look, its nosecap has been scorched. The harmony of its contours also became visible; a suprising perfection, developed by people, which made it possible for Buran to live in complete accord with the laws of physics, aerodynamics and many, many others. [Video shows nose of Buran, video pans back to show underbelly of Buran suspended from a large gantry, showing its heat-deflecting plates; Mriya is seen in the distance beneath it].

All this transport system is being made ready for flying to France for the Le Bourget international airshow, and the designers and engineers have left the damage which the craft received in flight. This proves that what will be displayed is not a model, but a real, flying machine. I will remind you that only four heat-protective plates were lost out of 39,000. [Video shows damaged plate]

Our report lasts only a few minutes, but the work for the docking went on for long hours. Just imagine the value of the load which was to be attached to Mriya's shoulders—a weight of tens of tons, and an accuracy of millimeters. I can tell you that after the international exhibition, the first Buran will return to Baykonur and will be reequipped and again made ready for spaceflight. But meanwhile—tests. [Video shows side shot of the loading operation, the AN-225 bearing the inscription USSR 480182, and what must be the supporting structure for receiving Buran clearly visible]

Tens, hundreds of sensors are fixed on the girder, and once again, the information will be received by scientists. [Video shows a woman attaching numerous wires at the base of a structural support—she is seen working out of a hatch on the upper edge of Mriya] It will be processed, interpreted and embodied in new ideas and machines, and the hope already exists that these ideas will also find embodiment in our daily lives. At the present time, the Congress of People's Deputies is setting the priorities. We hope that it will reallocate resources, take them away from insolvent people and departments and transfer them to those who are able to rework this money into contemporary projects and machines, including for our daily lives, for agriculture, and for our better life. [Video shows further shots of the Buran-mounting operation, in particular a shot of a docking port into which the supporting structure is being manipulated]

Buran, and the AN-225, Mriya, move out for the first time to the take-off-and-landing strip. [Video shows the two craft, Buran atop Mriya, being towed out onto the tarmac again] Each of these unique machines landed here independently, but it is the first time that they are faced with taking off together and landing. On this day, two runs were made along the strip up to the moment when Mriya's forward chassis lost contact with the earth. How do the machines behave? After all, on the one hand, Buran presses down with its weight upon Mriya, and on the other, its wings create an additional lifting force.

This stage in the tests passed excellently, and we will tell you about the first flight of the Mriya-Buran transport system in reports to come. [Video shows Buran and Mriya travelling along the runway, the forward wheels of Mriya lifting, and then coming down again. The video ends with a side shot of the two craft passing along the runway]

Shatalov Says Changes Likely in Design of Buran

LD1006201389 Moscow in English to Great Britain and Ireland 1900 GMT 10 Jun 89

[Text] Another mission aboard the Soviet orbiting space station Mir, currently unmanned, has been delayed until the end of August.

The chief of the Soviet space training center Vladimir Shatalov has announced that two special purpose add-on modules are to be docked with the station by the end of this year.

Shatalov said he was unable to announce the date for another flight by the Buran Soviet space shuttle. He said that data gathered during the first flight of the reusable craft was being processed. Shatalov said it was likely that experts would make some amendments to the design of the space shuttle.

UDC 629.19.01

Dynamics of Elastic Body in Gravity Field

18660167a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 24 Nov 88) pp 163-175

[Article by A. P. Markeyev]

[Abstract] A study was made of some aspects of the dynamics of a large spacecraft simulated by a continuous elastic body having internal damping. Motion occurs in a central Newtonian gravity field in a circular or elliptical orbit. It is assumed that the body is quite rigid and the damping time of its free elastic oscillations is much less than the characteristic time of motion of the body as a whole. The motion of the body, setting in after damping of the characteristic elastic oscillations, is attributable to gravity field and inertial forces (these motions are called "quasi-static"). A study is made of plane quasistatic motions of the body relative to the center of mass. The principal theorems of dynamics and Lagrangian equations of the second kind are used in deriving a closed system of differential equations describing the motion of such a body (these equations coincide with the known Santiny equations). The equations of motion are analyzed using a method similar to the asymptotic method developed by Chernousko for mechanical systems containing elastic and dissipative elements. In particular, it was found that in a quasistatic motion mode in a circular orbit the minimum potential energy of elastic deformations of the body may correspond to an unstable position of equilibrium of the body in an orbital coordinate system. For periodic oscillations of the body in a slightly elliptical orbit in the case of resonance it was possible to ascertain the critical eccentricity which when exceeded may cause these oscillations to become unstable. References 18: 8 Russian, 10 Western.

UDC 533.6.011.8

Aerodynamic Characteristics of Arbitrarily Rotating Bodies in Gas of Different Rarefaction

18660167b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 2 Jun 88) pp 180-185

[Article by A. I. Bunimovich and A. V. Dubinskiy]

[Abstract] In an earlier article ("Aerodynamic Computation of Bodies Rotating in a Flow on the Basis of Local Interaction Models," KOSMICH. ISSLED., Vol 23, No 4, pp 574-578, 1985) the authors generalized the concept of a local character of interaction between a body and a flow for the case of rotating bodies and formulas were derived for computing the forces and moments when there is rotation about the axis of the body for a quite general class of models taking in a great range of known flow conditions. Expanding on this earlier work, the approach is sequentially developed applicable to the case of arbitrary rotation of bodies in a flow. Figure 1; references: 8 Russian.

UDC 629.78

Analytical Evaluations in Problems of Nonlinear Stabilization of Spacecraft During Descent in Atmosphere

18660167c Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 23 May 87) pp 186-192

[Article by O. A. Privarnikov]

[Abstract] In earlier articles (IZV. AN SSSR: MEKHANIKA TVERDOGO TELA, No 2, p 60, 1974; No 1, p 41, 1976) the author gave approximate analytical relations for linear stabilization processes during descent of a spacecraft with a constant angle of trajectory inclination and later (KOSMICH. ISSLED., Vol 14, No 3, p 348, 1976; Vol 18, No 4, p 500, 1976) applied these relations in the stabilization problem for ballistic descent in linear and nonlinear formulations. Proceeding on the basis of this earlier work, a single differential equation is derived for the transient process in the case of a general nonlinear formulation of the problem. Conditions are stipulated which make possible the construction of approximate analytical solutions. These solutions are given for the case of an oscillatory transient process. Figure 1; references: 5 Russian.

UDC 531.31:681.5.037

Regular Asymptotic Approximation of Instantaneous Deviations of Aeromechanical Characteristics of Returnable Conical Spacecraft

18660167d Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 15 Apr 87) pp 193-205

[Article by A. V. Kostrov]

[Abstract] A method is proposed for analytical representation of deviations of the full ensemble of aeromechanical characteristics of a spacecraft. These deviations arise as a result of the effect exerted on the spacecraft by a high-energy impulse having, for example, an electromagnetic nature. The method relies on two fundamental models: a model of interaction between the impulse and the body in conformity to Lambert's law and a model of interaction between a hypersonic atmospheric flow and a spacecraft in conformity to Newton's shock theory. Expressions are derived for asymptotic expansions of first-approximation deviations in elementary functions. The systematic error of these expressions is evaluated. Figure 1; references 13: 9 Russian, 4 Western.

UDC 531.381

Control of Objects With Relay-Pulsed and Continuous Control Mechanisms Based on Algorithm With Predicting Model and Its Application in Dynamics of Spacecraft Rendezvous

18660167e Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 18 Aug 87) pp 206-213

[Article by N. Ye. Zubov]

[Abstract] A specific feature of some objects of control is that in the functioning process there is need for simultaneous control of both relay-pulsed and continuous-action mechanisms. An example is the trajectory of a spacecraft with one or two constant-thrust engines. In this case the engines are the relay-pulsed control mechanisms and the continuous-action control mechanisms are the direction cosines of orientation of the thrust vector in the selected coordinate system. Various algorithms have been proposed for the control of dynamic objects, but none are adequate for the formulated problem. This article gives a variant of an optimal control algorithm with a predictive model reproducing motion of an object in accelerated time. The theory which is formulated is applied, as an example, to rendezvous of two spacecraft in an orbital coordinate system. Figures 4; references: 5 Russian.

UDC 539.165

Planning of Spacecraft Launchings and Servicing of Regions on Earth With Allowance for Their Illumination and Restrictions on Functioning of Spacecraft Optoelectronic Instruments

18660167f Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27 No 2, Mar-Apr 89 (manuscript received 8 Apr 87) pp 214-220

[Article by I. D. Ibragimov and B. S. Skrebushevskiy]

[Abstract] A graph-analysis method is proposed for determining the date and time of launching of a spacecraft ensuring a maximal duration of servicing of designated regions on the Earth's surface, taking into account restrictions on the functioning of optoelectronic instruments. The procedures involved are as follows: 1) Determination of onset of illumination conditions for a particular region and the corresponding time intervals; 2) Determination of the conditions for onset of situations favorable for spacecraft operation with allowance for limitations on the optoelectronic instruments and entry of the spacecraft into shadow zones and determination of the corresponding time intervals; 3) Selection of the range of dates for possible launchings of spacecraft during which there is assurance of the required angles (Sun- spacecraft-serviced region; Sun-spacecraft-center of Earth). The method makes it possible to determine the launching date with an accuracy to several days and the launching time to several minutes. The launching date and time can be made more precise, in case of necessity, by using adequately precise mathematical models. Figures 2; references: 4 Russian.

'Cosmos-1870' Satellite Mission Concludes

LD3007155489 Moscow TASS in English 1547 GMT 30 Jul 89

[Text] Mission Control Center July 30 TASS—A protracted space mission, involving the Cosmos-1870 artificial earth satellite put into orbit on July 25, 1987, has concluded.

The mission program included testing methods of long-distance probing of the earth with the help of the first Soviet-made all-weather high definition radar station.

During the two-year operation of the Cosmos-1870 satellite, radar scanning of the earth's surface, including natural formations on the territory of the Soviet Union and some other countries as well as extensive areas of the world ocean, yielded numerous pictures which fully confirmed the radar station's technical efficiency and the efficiency of the satellite's universal space platform capable of carrying research apparatus weighing up to four tonnes and providing a base for installing various-purpose space equipment.

The materials obtained have been transferred to the state "Priroda" research-and-production center, the Space Research Institute of the USSR Academy of Sciences, the Institute of Radiotechnology and Electronics of the USSR Academy of Sciences and other organizations for use in the interests of science and the country's economy. Some materials have been transferred to specialists in France, Finland, Sweden and the United States of America.

Today, the mission control center issued commands to change the space orientation of the Cosmos-1870 satellite and to set its engines in motion. As a result of the slowing-down, the satellite entered a descending trajectory and ceased to exist in the dense layers of the atmosphere above the designated area of the Pacific Ocean.

Commentary on Mission of Cosmos-1870 Radar Satellite

18660202 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 1 Aug 89 p 3

[Article by G. Yefremov, Hero of Socialist Labor, Laureate of the Lenin Prize and the State Prize: "On the Completion of the Flight of the 'Cosmos-1870' Satellite". First two paragraphs are introductory paragraphs in source.]

[Text] Cosmos-1870 has completed its two year mission in Earth orbit. It was launched on July 25, 1987 from the Baykonur cosmodrome on a Proton booster.

G. Yefremov, Hero of Socialist Labor and Laureate of the Lenin Prize and the State Prize, discusses the mission of Cosmos-1870.

This time the modest name of the regular Cosmos satellite was conferred on a heavy automatic long-term orbital station designed for comprehensive studies of Earth. It was developed by a design team under the direction of Academician V. N. Chelomey.

The station, which weighed 20 tons at launch, had a mass of 18.5 tons at the beginning of its orbital flight. Four tons of that weight was the research equipment complex.

The foreign press acknowledged that Cosmos-1870 was a very significant and promising achievement of Soviet space technology. The Washington Times of August 21, 1987 reported this about the launch: "An analogous American spacecraft will be launched in no less than eight years, and it will be equipped with radar and various other sensors designed for interaction with the on-board radar station." The US Congress and NASA praised the Cosmos-1870.

However, the Soviet Union could have completed these programs and put them to practical use much earlier if the stagnation of the 70s and 80s hadn't influenced the fate of Chelomey's automatic orbital station.

The first station of this type was manufactured, tested on Earth, and prepared for launch at the Baykonur cosmodrome in July 1981. An initiative of D. Ustinov cancelled the launch. In December of 1981 all work on the project was suspended. Work resumed six years later, and efforts were crowned with the launch of Cosmos-1870, a station saved from destruction by the efforts and concerns of teams of developers, the manufacturer, and the testers.

Cosmos-1870 completed its assignments. The huge amount of material obtained in the course of the two-year operation of the station in orbit will be subjected to careful study in the country's specialized scientific institutes. Over the two year period, radar photographs were taken of an area about five million square kilometers in size, including regions which are virtually inaccessible for regular photography. Materials were obtained on the structure of geological formations, as well as data on descriptive and dynamic geology.

An analysis of the radar photographs made it possible to find new uses for this method of observation. For example, subsurface sounding makes it possible to uncover deposits of fresh water beneath arid and desert regions and active tectonic structures beneath friable surface layers of soil.

It was found that radar observation is very effective for hydrological research, revealing the relief of the underwater shelf. Shoals, banks, and underwater mountains were discovered.

Regularly repeated observations in all weather reveal changes caused by elemental phenomena (earthquakes, floods, mudslides, etc.), as well as the effects of man's activity (flooding, construction of dams and city roads, etc.)

However, the abundance and richness of information obtained from Cosmos-1870 will produce the necessary yield only when it is processed with special precise methods on appropriate equipment by enough skilled specialists. At present, work is not proceeding as it should. As things are now, the processing of materials from only one Cosmos-1870 will drag on for years.

The experience of the two-year operation of Cosmos-1870 has taught much. Primarily, it proved that spacecraft of this type can be used effectively in the interests of the national economy.

A number of foreign agencies have requested Cosmos-1870 materials, and this indicates the possibility of obtaining a monetary return for this territory information from foreign governments.

Spinoffs to Civil Economy From Formerly Classified Facilities

186600175 Moscow TRUD in Russian 19 May 89 p 1

[Article by V. Golovachev, special TRUD correspondent: "The Space Program and Economics: What the Space-and-Rocket Sector Can and Does Give the National Economy"]

[Text] In the quite recent past, access to this place—little more than a secret "post office box" engaged in the development of new materials—was very limited not just for journalists, but also for specialists from related, also "closed" enterprises. Today the "Kompozit" scientific production association of the USSR Ministry for General Machine Building opened its doors to journalists who inspected the astonishing super-modern buildings for several hours, convinced first hand of what conversion is.

Stanislav Petrovich Polovnikov, the association's general director and the director of the Central Scientific Research Institute for Materials Science, was our friendly guide, escorting us through the large exhibit that explains how broad the applications can be for the materials, technologies, and products created at the enterprises in and the organizations of the Ministry of General Machine Building. That is, at the enterprises where the latest space and rocket equipment is being developed.

All the best that the sector has to offer is gathered here. Rocket fairings and unusually designed water faucets, "Phobos" equipment and unique medical instruments, the world's most powerful rocket engines—those of "Energiya," which took the reusable "Buran" into space—and knives for commercial meat cutting are, as it were, improbably juxtaposed with one another in the spacious halls...Sometimes you got the impression that you were making a trip into the future, to some fantasy world shockingly different from the one in which we live...And you can't help but be surprised at how much the space program can give the national economy and how little our economy draws from this invaluable source.

Here's you have one of the simplest things around—a water faucet. But it even looks different from the ones we are accustomed to: you don't have to twist anything open or closed to turn the water on or off. The stream of water is adjusted by a metal lever which you smoothly raise or lower. But it's not a matter of external differences—rather, it's one of structural differences. There are no washers to constantly malfunction and annoy the user. There are only two ceramic disks, which have three holes; the disks are placed together and can shift relative to one another—and that is the entire secret of the new faucet's design. The ceramic, which was developed for space vehicles, has super-high strength. The faucets won't malfunction, leak, drip, etc., for decades. Their use would save us 28 million rubles. Starting in 1993, the "Kompozit" scientific production association will begin to produce a million pairs. Yes, the association is doing the maximum possible. But what is a million faucets to our country? I think they could get other enterprises involved. However, for some reason not many are interested. But if the faucets were also put on the foreign market...

And pipes? All we're ever doing is forever replacing rusted pipes. We dig them up, we replace them, and cover them up. Then we dig them up again, replace them...But if we were to make them from polymer composites, they wouldn't wear out. Every thousand tons of casing pipe made of composite materials for the oil and gas fields would save 23.5 million rubles. A good example is the city of Voskresensk, where a 120-meter-high smokestack was built 14 years ago. The inside of it is coated with a layer of a petroleum-based plastic. Ordinary pipe would have needed to be repaired more than once. But this one performs without trouble. The gain is two and a half million rubles.

Last year 2,000 tons of high-strength composite materials were used in our national economy; 150,000 tons were used in the USA. Is there a difference? If we were to achieve the American level, then the annual savings would be tens of billions of rubles...

In the next hall we saw an even more impressive exhibition—the possibilities for using new materials in medicine. Everything imaginable was there! But the nagging question kept arising, when will all this appear in the clinics to help heal patients, to give back the most precious thing—health—to people? Admittedly, some of it is in use, but only a miserly portion. However, now it looks like the ice is beginning to break up. A joint program of the Ministry of General Machine Building and the Ministry of Health has been adopted. Its implementation will mean a serious step forward in the introduction of innovations in medicine. The "Kompozit" scientific production association, for example, is creating a special shop for production of endoprostheses.

The main payoff in medicine is people's health. In the national economy, the introduction of the achievements of the space program, of the innovations presented at the exhibit, has an economic impact measured not just in the millions, but in the tens and hundreds of millions of rubles.

Has anyone tried to add up all these millions? You'd get a tidy sum. And the biggest insult is that only a small portion of the innovations are being implemented in the national economy today. According to estimates, it a few percentage points, that is, less than a tenth. But even this has an explosive effect. How much greater it would be if innovations were to be introduced on a broad scale. Dozens of new, unique materials were developed just for the "Buran" alone. The switch to composites would make it possible to save millions of tons of steel alone every year and would provide a considerable additional capital, including hard currency.

We buy what we need, for example, of special knives for commercial meat cutting from the FRG (for two million rubles). However, the "Kompozit" scientific production association will now produce these knives from super-hard metal developed for the "Energiya" rocket system. The qualities of the prototypes turned out to be just as good as those of the German products. The savings is 12-15 million rubles.

But one scientific production association, even a very powerful one like "Kompozit," cannot replace the entire national economic complex. The association is already taking a considerable burden on its shoulders. It is time to seriously involve others.

There are no more secrets here. The exhibit is ready to receive all interested specialists. (Although, to be honest, it would have been better to organize it at the Exhibition of the Achievements of the National Economy than behind a tall fence). The economic levers are still not fully operative, and it would apparently be worthwhile thinking about how to actively pursue mass dissemination of the valuable innovations in a centralized fashion (using the system of state orders, for example).

There is a lot of talk about the practical yield of the space program and of the development of manned flights. The exhibit is one more clear, vivid confirmation of what a great leap forward the rocket-and-space sector is effecting. But still, what direct effect does the national economy derive? If we take it as a whole, last year expenditures for the space program in our country amounted to 1.3 billion rubles, while the economic impact derived (from communications satellites, space photography, spinoffs, etc.) was about two billion (we can finally quote these figures). The net profit, for example, is 700 million rubles. By the way, in the United States, NASA was allocated $9 billion in 1988. As we know, they don't throw money to the wind over there. It's food for thought...

Applications of Space Industry Technology in Economy

Spinoffs From Space Sector Cited

18660176a Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 18 May 89 p 4

[Article by Yu. Semenov, chief designer, Energiya Scientific Production Association, corresponding member, USSR Academy of Sciences, under the rubric "Science and Technology: News": "Earth Gives to Space, Space Gives to Earth"]

[Text] The space program stimulates the development of the most advanced technical sectors of the country. Many interesting and important developments got their start and won the right to be, thanks to space research.

However, when people speak of the practical benefits of the space program, more often than not they speak of communications satellites or weather satellites, that is, only of the direct application of space equipment. Meanwhile, the development of apparatus and work methods, the preliminary research and ground tests, and various aspects of materials science produce no fewer spinoffs that, surprising at first glance, enable the successful application of advanced space technologies in the economy.

Most of them have been developed right in the organizations engaged in the creation of space equipment, whereas others have been produced by other industrial enterprises on special order and, consequently, with space sector financing.

The high level of organization of operations in the space program should be mentioned. Advancing to the leading edge of development in science and technology required new planning and accounting principles and cooperation among a great number of development workers. The Council of Chief Designers created an environment in which there was businesslike cooperation and in which the specialists of the various ministries and departments exhibited a high level of responsibility; that made it possible to perform a good many difficult tasks in relatively short periods of time. That experience can be of great assistance in devising organizational systems for managing the economy.

In presenting to you this report on new developments that have been brought about through the participation of the Energiya Scientific Production Association, I would like to note that this represents only a small part of the technologies that have been transferred and whose use, according to the roughest estimates, has had an overall impact in the billions of rubles.

To that should be added the advances made during the development of systems for control, communications, and data processing; medical equipment; and many other fields. I should hope that this sort of publication will give serious food for thought to those who are

fighting for a reduction of expenditures on the space program in the state budget. Today possibilities are appearing for greater openness, and that will definitely help to augment an intensified introduction of the advances associated with space equipment.

Low-Temperature Alloys

18660176b Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 18 May 89 p 4

[Article by L. Bunin, V. Sergeyev and A. Plotnikov, candidates of technical sciences, under the rubric "Science and Technology: News": "When the Cold is Not a Threat"]

[Text] In 1924, the first all-metal Soviet aircraft, the ANT-2, designed by A. N. Tupolev, took to the skies. After aluminum alloys, the list of "winged metals" included various grades of steel, titanium and beryllium. The growth of the space program, however, stimulated the development of new structural metal alloys.

Do many know that the skin of the Soyuz ships is only a few millimeters thick? Nevertheless, this thin, almost "transparent" skin reliably shields the crew against the space vacuum.

But the level of space metal research can be illustrated by a more graphic example. The specific strength of structural alloys is sometimes measured in kilometers: the maximal length of a wire suspended at a single point and supporting its natural weight. Well, for some new materials this index is 30-35 km, truly a "space altitude." Compare that with the specific strength of the "stainless steel" familiar to all—only 7 km.

In order to achieve such high performance it was necessary to introduce new, progressive methods. And the methods in themselves are enhancing the technological potential of the sectors. For example, the mastery of the method for vacuum-plasma refining in a rotating mold will make possible a 25% reduction in losses of steel during its production.

Looking to the future, scientists are pinning more and more hope on liquid hydrogen. First, sooner or later the petroleum reserves on the planet will be exhausted. Second, hydrogen is an energy-intensive, ecologically clean fuel. But what is still the distant future for transportation is today's reality for the space program. The Energiya rocket operates on liquid hydrogen. That means that some materials developed specially for the rocket can be used in future designs of aircraft, automobiles and ships. They are also suitable for some other sectors that are ready to use liquid hydrogen as a fuel.

And the alloy 1201 can already be used effectively in traditional cryogenic machine building—it is two or three times stronger than chromium-nickel steels. "Space" metal can sharply increase the useful life of machines and mechanisms operating in the Far North. Indeed, it is well known that in the severe freezes there, ordinary steel becomes almost as brittle as glass. According to our computations, the cryogenic alloys developed for Energiya are capable of prolonging the lifetime of machines created for use in the North by a factor of 2.5-3.

Special Materials

18660176c Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 18 May 89 p 4

[Article by V. Burlutskiy, doctor of technical sciences, V. Koloskov and V. Ryzhikov, candidates of technical sciences, under the rubric "Science and Technology: News": "And It Does Not Burn in Fire"; first paragraph is introduction in source]

[Text] **"We burst into the atmosphere like a fiery bolide. Scarlet laces of plasma streak across the glass of the ports. We are, as it were, flying in a fireball." That is an excerpt from a book by the cosmonaut A. Berezov, titled "211 Days in Orbit." What kinds of resistant materials must be used in the facing of a spaceship so that it can withstand a firestorm whose temperatures reach 10,000 degrees?**

The Soyuz ships are protected by composite materials that, when exposed to high heat fluxes, suffer the destruction of only a relatively thin surface layer; whereas inside they remain "cold." Such coatings as those that are subjected to destruction are, of course, needed only by space-and-rocket systems. But the materials they are made of (glass fillers, heat insulators, adhesives, sealants) are widely used in the national economy.

For example, the heat-resistant materials developed for space equipment at the Stekloplastik Scientific Production Association of the Ministry of the Chemical Industry are now used in aviation, electrical engineering, shipbuilding and metallurgy. Their use for the filtering of acidic and neutral solutions and for screening impurities from gases as a result of increased temperatures is producing a savings of no less than a million rubles in metallurgy alone. But the total savings has already exceeded a billion. We hope that these figures will force those who consider the space program to be a "parasite" on the national budget to give this matter some thought.

Work on the reusable Buran required the development of truly unique materials. That same Stekloplastik Scientific Production Association gave birth to a silica-fiber material which, at low density, has splendid heat-insulating properties. Aviation and electronics are now paying very close attention to it—its use promises to produce a savings of, at minimum, 3-5 million rubles.

The "windward" surfaces of the Buran—the leading edges of the wing and tail fin and the nose cone—are heated to 1600 degrees during aerodynamic braking in the atmosphere. The disintegrating thermal shielding of the Soyuz is no good here—what kind of a reusable ship

would that be? Carbon- fiber materials and carbon-carbon composites were developed for the Buran. The space "shuttle" itself has gone into orbit only once, and the materials designed for it are already widely used in industry. And no wonder—work on them began back in the 1960's.

At the enterprises of the Ministry of Nonferrous Metallurgy and the Ministry of the Electrical Equipment Industry graphitic-carbon felt is used to insulate equipment operating in a vacuum at temperatures up to 2000 degrees and, in inert media, at even higher temperatures. Nonfabric carbon materials, in removing harmful substances from solutions, considerably improve working conditions in electroplating workshops. Carbon fabrics are excellent heating elements. The range of their applicability is extremely broad: from electrical hardening furnaces to household appliances—heaters, blankets, and heatable suits for welders working in the Far North. The anticipated savings is about 3 million rubles.

The desire to protect space equipment against high temperatures prompted the development of reliable electrical insulation materials which, naturally, did not go unused. It was those materials that made it possible to develop fundamentally new types of electronic equipment that can withstand temperatures of up to 700 degrees instead 200, as before. Such equipment has now been supplied to 30 enterprises of various sectors. The savings is more than 8 million rubles annually. Organosilicate materials are used by more than 500 enterprises. The annual savings is more than 5 million rubles.

There is no sense in continuing to list examples, because there are dozens of them. We will mention what is most important: expenditures on materials science research for space equipment fully pay for themselves and, in some cases, pay for themselves five or ten times over. Nevertheless, at the present time there is a tendency to cut back spending in this area; they say that it is necessary to cut down on the sums allocated for space programs. You certainly can't saw off the limb you're sitting on. After all, pioneering materials science research is needed not only by space, but also by the entire country. And what will happen if the teams who have accumulated solid theoretical experience and who have developed original experimental methods are switched over to the solution of other problems? The answer is obvious: we will lose experience, we will lose our leading position in a whole series of fields, and, finally, we will need to retrain specialists who are accustomed to solving seemingly insoluble problems and are fanatically dedicated to their work.

Paints and Coatings

18660176d Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 18 May 89 p 4

[Article by G. Lunina, G. Komotskaya and A. Kopylov, candidates of technical sciences, under the rubric "Science and Technology: News": "What They Paint Rockets With"; the first paragraph is an introductory paragraph in source]

[Text] **A number of original paint-and-varnish coatings have been developed by specialists for the Energiya-Buran rocket-and-space system. These materials can and should be used extensively in the economy.**

Why do we paint any object? Ask this question of the first person you meet, and he answers: for beauty. Imagine if all the colors of things suddenly disappeared—how cheerless life would become, and how bored we ourselves would probably be. Space is no exception. Chemists have developed enamels of soft pastel tones for the living quarters of spaceships. But the soft, unobtrusive range of colors is not their only merit. Space equipment always has its special requirements. The enamels are not simply beautiful; they do not burn, they do not release harmful chemical compounds dangerous for the crew's health, and the technology for their application is ecologically harmless. These qualities would far from irrelevant on the Earth, for example, in the finish work of dwellings and hotels.

But now ask that same question of a specialist, and he will answer: we paint an article primarily to protect it against corrosion, which annually eats up approximately a tenth of the entire world production of metals. But that is not all: scientific and technical progress has become the "godfather" of coatings with previously unknown properties—such as electrically insulating coatings or, just the opposite, current-conducting coatings and chemically resistant, temporary coatings easily removed when there is no longer a need for them.

Specialists of the Energiya Scientific Production Association, in collaboration with leading scientific research institutes of the aviation and chemical industries, have developed a whole series of such coatings. For example, the EP-0214 primer reliably protects aluminum alloys and steels against corrosion. It "sticks" wonderfully to metal and, most important, retains elasticity in a very broad temperature range—from -253 to +200 degrees. Why this is necessary is understandable—after all, the Energiya rocket operates on liquid hydrogen. But could it not be used in other branches of cryogenic technology?

When a rocket is being prepared for launch, static electricity charges accumulate on it and on the units of the launch complex. An accidental spark is fraught with the danger of a fire or an explosion, especially if the fuel is liquid hydrogen. Antistatic heat-regulating coatings help in eliminating the charges. They can also find application on the ground, at computer centers, for

example, and even beneath the ground, in mine shafts, where protecting equipment from explosion is an extremely acute problem.

The heating, current-conducting, nontoxic and nonfuel coating AK-5260, on which the electrically insulating, emerald-colored enamel VAS-980 is applied, ensures the thermal regime of some spaceship units and systems. The compact, beautiful heaters for port windows and for compressed gas cylinders are made from such a "sandwich." You don't have to explain to an experienced technician where and how such coatings might be used.

But most of these innovations are virtually unused in the economy. In part, this is attributable to the lack of broad, open information. In part, it is attributable to the fact that they have been given the tags "specially reserved" and "special purpose" materials. Moreover, they are produced in small quantities (which increases their cost appreciably) from raw material which is supposedly in short supply (but what isn't in short supply in our country?). Such a situation can and must be rectified.

French Experiment To Be Flown on 'Photon' in April

LD1704174189 Moscow TASS in English 1625 GMT 17 Apr 89

[Text] Moscow April 17 TASS—The first commercial launching of the Soviet automatic space vehicle "Photon," fitted out with French scientific equipment, has been scheduled for the end of April, a TASS correspondent was told at Glavkosmos of the USSR. This is envisaged by the agreement between the foreign economic association "Licensintorg", representing the interests of Glavkosmos, and the National Space Research Center of France, signed last summer.

The French national centre's scientific equipment has already arrived in the Soviet Union, where it is undergoing pre-start tests with the participation of French experts. The experiments that will be carried out on board the "Photon." On French orders have the purpose of obtaining certain scientific data in the field of imponderability physics. After the flight program is completed, the scientific equipment and accumulated information will be returned to French specialists.

At present the Soviet Union is placing Soviet space technology at the disposal of foreign organisations and firms on commercial terms. One of them is that the experiments should be carried out in conditions of microgravitation on board the "Photon" automatic space vehicles, which are, in fact, space laboratories. The "Photon" technological complex permits to stage experiments on board, linked with the production of semiconducting, optical and polymer materials, to carry out space materials studies and biotechnological research.

"Photon" space vehicles have a number of advantages over foreign analogues, it was stated at Glavkosmos. The main ones include their relatively low launching costs, comparatively long (up to one month) stay on the orbit, their reusability and big retrievable payload (up to 500 kilograms). The vehicles' structural features ensure a low level of gravitational impacts on the materials subjected to space tests and the equipment's safety during reentry and landing.

'Photon' Satellite Launch Preparations Detailed

LD2604094889 Moscow Television Service in Russian 1700 GMT 25 Apr 89

[From the "Vremya" newscast]

[Excerpts] [Newsreader] Soviet and French specialists have completed preparations at the Plesetsk cosmodrome for the launch of the "Photon" scientific satellite:

[S. Slipchenko, identified by caption] [passage omitted] "Photon"—That is the name of the satellite taking us nearer to factories in orbit and the descent module will bring back to earth the basis for new medicines, new alloys, and new optical materials. "Photon" will bring, as they say, "clean money." The French firm Matra will pay hundreds of thousands of dollars for the commercial payload, an apparatus weighing 20 kg. Western firms know how to count money and that means that the game is worth the candle. One can say that commerce has begun on Soviet space apparatuses, and not to the detriment, but in parallel with the national program of research. [video shows diagram; module moving along a track slowly inside a hanger-type building; onlookers; pair of red, amber, and green lights; diagram then close-up of the "Photon" commercial apparatus; men carrying a container in same area]

Plesetsk cosmodrome. [passage omitted] Rockets go up straight from the forest, the taiga; weather in the north goes from sunshine to snow several times a day; they were lucky this particular morning as the rocket was taken to the launch position; this is one of the oldest launchpads in the country, more than 300 space apparatuses have been launched from there. [video shows lettering MATRA ESPACE: PROJET SBS-SEPH; MV, on object in close-up; more views inside the hangar; travel on a road in the taiga; same module as before on the move outdoors; views of launchpad]

The "Photon" has the ordinal number five, but this is the first satellite on board which there is a foreign commercial payload. It would be good for Soviet organizations to also raise the level of their research to the sphere of space technology. [passage omitted] [video shows views of launch area, close-ups of the apparatus in launch position, a man and woman looking on]

There are many specialists present today as it is brought out, including those from the Institute of Medico-Biological Problems. Engineers and designers from the Alloys Technical Center are perfecting and working on their equipment.

[V.D. Kozlov, chief of the "Photon" design bureau of the USSR Glavkosmos, identified by caption] Many foreign firms and organizations are interested in the possibility of installing apparatus on our space apparatuses. In the future we propose developing this work and transferring to obtaining materials in space on an industrial basis. For this aim we are developing a series of space apparatuses in the Nika series. These space apparatuses will ensure the return to earth of up to 1,200 kg of those materials which will be obtained in space and technological installations.

[Slipchenko] Is this fantasy or is it nonetheless a reality to transfer to financial autonomy at least this direction of cosmonautics?

[Kozlov again] In my view, this direction is not a fantasy but a real requirement of our life. [video shows Kozlov and Slipchenko speaking outdoors at the launchpad site; more views of the launchpad and surrounding taiga; distant shot of the apparatus in position, seen through the trees]

[Slipchenko] On board "Photon" stand furnaces, protein crystallizers. Today there are several tens of experiments and the main thing is that both the descent module and instruments will be used on more than one occasion in future space flights. The "Photon" launch has been fixed for 26 April at 2100 Moscow time [1700 GMT]

'Photon' Satellite Launched on 16-Day Flight 26 April

Parameters of Orbit Given

LD2704072189 Moscow TASS in English 0713 GMT 27 Apr 89

[Text] Moscow April 27 TASS—The Soviet Union on Wednesday [26 April] launched a satellite for continuing space materials studies.

The satellite, Foton, was orbited by a Soyuz booster.

The program of the 16-day flight includes experiments to produce semi-conductor materials with improved qualities and extrapure biologically active preparations in microgravity and study processes involved in this.

In keeping with a commercial agreement, Foton carries French research equipment.

After the flight program is fulfilled, produced materials will be brought to earth.

The satellite was delivered to an orbit with the following parameters:
Initial period of revolution—90.5 minutes,
Maximum distance from earth—402 kilometres,
Minimim distance—225 kilometres,
Inclination—62.8 degrees.

The satellite's equipment is functioning normally.

Details of Program Given

LD2704093189 Moscow TASS in English 0747 GMT 27 Apr 89

[Text] Moscow April 27 TASS—A "Photon" satellite was put in orbit on Wednesday by a "Soyuz" booster. The flight program includes obtaining super-clean semiconductors, biologically active substances, protein crystallization and other technological experiments.

The satellite is designed for the study of materials in space. The first satellite designed for the study of materials in space, Cosmos-1645, was launched in 1985, followed by Cosmos-1744 in 1986.

Cosmos-1841 which blasted off in 1987, the first Photon put in orbit last year, and the satellite just inserted in orbit on Wednesday—are the same apparatus. Specialists jocularly refer to it as a mini-shuttle. When it returns back to earth, the specialists restore its heat-protective shield and certain equipment components, and the rest continues to serve during the next flight. The satellite is expected to stay in orbit for 16 days.

Technological installations on board the Photon include "Splav-2" designed for a directed volume crystallization of semi-conductor materials and glass. Super-clean semiconductors obtained can be used in radioelectronics to manufacture large integrated circuits, as material for solar batteries and in other fields. Glass is used to make light-guides and flat lenses with improved performance characteristics.

The "Kashtan" installation divides and cleans proteins by an electrophoresis technique. An electric field arranges proteins in a definite order of acidity. In the present flight, the intention is, among other things, to obtain an Alpha-1 thymosin protein which is the basis for drugs to treat immunodeficiency.

Another protein crystallization experiment is to look into the protein structure. The fact is that crystals, obtained in conditions of the earth's gravity are too small to be seen even in an electronic microscope.

On board the Photon, on a commercial basis, there is also present a French device to study the behaviour of liquids in zero gravity.

The study of materials in space will be continued with the use of a special technological module which may be docked with the orbital "Mir" complex this year. The 1990s may see launchings of "Nika" satellites to conduct technological experiments. They will have a longer life span and better weight and energy parameters compared to those of the Photon.

Return Apparatus of 'Photon' Satellite Lands

LD1205100989 Moscow Television Service in Russian 1700 GMT 11 May 89

[Text] The return apparatus of the technological satellite "Photon" landed in the Orenburg region today. This is

the only space laboratory production complex in the world which makes it possible to obtain in orbit substances and materials of unique properties. [video shows a round object connected to a large parachute after landing, a person trying to unscrew the opening, helicopter flying above]

An instrument made by French scientists was placed on board the satellite for this flight. "Photon's" work was successfully completed. According to a report by our correspondent, the analysis of the information delivered to earth will start today. [video shows a group of people who, having opened the satellite, are looking inside and taking a component out and placing it in a reinforced box]

Space Officials Describe 'Photon' Project

LD1605175989 Moscow TASS in English 1729 GMT 16 May 89

[Text] Moscow May 16 TASS—The fifth flight of a purpose-built technological satellite, Photon, is an important stage in the work in the material studies field, which has been conducted in the USSR for over ten years now, Aleksandr Dunayev, head of the USSR Chief Administration for the Development and Use of Space Engineering for the Economy and Research (Glavkosmos), told a news conference today.

The Photon satellite was propelled into an orbit by the Soyuz booster-rocket from the Plesetsk spaceport on April 26 and on May 11 its descending module landed in the area of Orenburg.

By the way, the same landing craft was used during the two previous launches of the Photon. The scientific equipment aboard the satellite weighs 405 kilograms. Its technological plants were used to conduct experiments to grow crystals, weld semiconductors, metal and optical materials and bioexperiments.

Their results are important to basic science but can also find application even now in medicine, the electronic industry and other areas. According to Dunayev, the flight cost 6.5 million roubles.

It was for the first time ever than an instrument manufactured by the French firm Matra was installed in the Soviet satellite on commercial terms. It is designed to study the conduct of liquids and gases in zero gravity conditions.

"Experiments in material sciences are conducted both in unmanned satellites and at the Mir orbital station", Dr Vitaliy Tatarchenko, deputy director of the Kompozit Science and Production Association, noted. "In several cases it is impossible to do without a man, although the presence of a cosmonaut creates microgravitation and can disrupt, for instance, the protein crystallization process. When we practice the technology to a sufficient degree, it will be possible to switch totally to materials production aboard pilotless spacecraft".

Vladimir Kozlov, head of the Photon Design Bureau, said a purpose-built technological satellite, Nika, is under development now to replace the Photon in the next decade. It will have a by far longer service life in orbit—120 days instead of 16 and a big power to weight ratio. The mass of the technological equipment returned to earth will increase to 1,200 kilograms.

Dunayev recalled that a technological module, in which semiconducting materials in quantities of up to tens of kilograms will be obtained, will be docked to the Mir station right after the service module. He added that blueprints of purpose-built platforms—space factories at which hundreds of kilograms of miscellaneous materials can be produced—are being drawn up even now.

[Moscow Domestic Service in Russian at 1500 GMT on 16 May carries a brief report on this press conference which attribtues the following remarks to Dunayev: "A new crew will be launched to the Mir orbital station in August. It will have to ensure the docking of the station's two scientific modules. Dunayev also said that the 'Photon' technological satellites are being replaced by larger apparatuses capable of operation in orbit for several months."]

Aerospace Experiment Monitors Soviet Reservoir

PM1107103989 Moscow PRAVDA in Russian 1 Jul 89 Second Edition p 2

[Report by own unnamed TASS correspondent: "Space Portrait of Reservoir"]

[Text] As your TASS correspondent was informed at the Intercosmos Council, an international aerospace experiment called "Internal Reservoirs—Intercosmos-89" was carried out in the Soviet Union over the Rybinskiy Reservoir from 15 to 30 June. Specialists from Bulgaria, the GDR, Poland, the Soviet Union, and Czechoslovakia took part.

The aim of the experiment is to develop methods of monitoring the state of internal reservoirs and drainage systems from space. Measurements were taken over the Rybinskiy Reservoir at three levels: from the national economic satellites "Resurs-F" and "Cosmos-1939," from aircraft and helicopters, and from USSR Academy of Sciences scientific research vessels.

The information obtained is being processed by scientists and will be used to advance CEMA countries' economic interests.

Launch of 'Resurs-F' Satellite 25 May

LD2605080189 Moscow TASS in English 0750 GMT 26 May 89

[Text] Moscow May 26 TASS—The Soyuz booster rocket launched an artificial earth satellite, Resurs-F, in the Soviet Union on May 25, 1989. It was developed by the Photon design bureau of USSR Glavkosmos, Chief

Administration for the Development and Use of Space Engineering for the Economy and Research.

The satellite carries photographic equipment for large-scale multizonal and spectrozonal scanning to carry on the exploration of the earth's natural resources in the interests of various branches of the USSR national economy and international cooperation.

The satellite was put into an orbit with the following parameters:

—Initial period of revolution - 88.7 minutes,
—Maximum distance from the earth's surface (apogee) - 263 kilometers,
—Minimum distance from the earth's surface (perigee) - 188 kilometers,
—Orbit inclination - 82.3 degrees.

The equipment installed in the satellite operates normally.

The incoming information is transfered to the USSR Priroda State Research and Production Center for processing and use.

The Resurs satellite also has two "Pion" passive separated satellites to study the density of the upper atmosphere, which were developed by the collective of the student design bureau of the Korolev Aviation Institute in Kuybyshev.

Three 'Cosmos' Satellites Launched For Navigation, Spacecraft Positioning

LD0106081189 Moscow TASS International Service in Russian 0741 GMT 1 Jun 89

[Text] Moscow, 1 June (TASS)—Three artificial earth satellites, "Cosmos-2022," "Cosmos-2023," and "Cosmos-2024," were launched by the "Proton" carrier rocket in the USSR on 31 May.

The "Cosmos-2022" and "Cosmos 2023" satellites are intended for the testing of elements and apparatus of the Glonass global space navigation system, being created for the purposes of determining the position of civil aviation aircraft and vessels of the maritime and fishing fleets of the Soviet Union.

The main task of the "Cosmos-2024" satellite is to ensure the reception of information for increasing accuracy in the determination and forecasting of the movement of space apparatuses, and also for geodesic and geophysical research.

The satellites have been placed in an orbit close to a circular one, with the following parameters:

—initial period of revolution—11 hours 15 minutes;
—distance from surface of earth—19,140 kilometers;
—orbital inclination—64 degrees.

The apparatus aboard the satellites is working normally. The coordinating and computing center is processing the incoming information.

'Molniya-3' Communications Satellite Launched

LD0906070389 Moscow TASS in English 0701 GMT 9 Jun 89

[Text] Moscow June 9 TASS—The Molniya booster-rocket launched a communication satellite, Molniya-3, next in the series, in the Soviet Union on June 8, 1989 to ensure the operation of the long-distance telephone and telegraph radio communication and the broadcast of Soviet central television programs to the Orbita network and international communication centers.

The satellite was put into an orbit with an apogee of 40,696 kilometers in the northern hemisphere and perigee of 631 kilometers in the southern hemisphere. The satellite's period of revolution is 12 hours 17 minutes, orbital inclination is 62.9 degrees.

Communication sessions via the Molniya-3 satellite will be conducted under the scheduled program.

'Raduga-1' Communications Satellite Launched 22 June

LD2206120689 Moscow TASS International Service in Russian 1210 GMT 22 Jun 89

[Text] Moscow, 22 Jun (TASS)—The "Raduga-1" communications satellite was launched by a "Proton" carrier-rocket in the USSR today. On board is a multichannel relay apparatus ensuring further expansion of telephone and telegraph radio communication on the territory of the USSR. The satellite has been put into a stationary orbit with the following parameters: Distance from the earth's surface—36,538 km; period of revolution around the earth—24 hrs, 32 min; inclination of orbit—1.5 degrees. The apparatus on board the satellite is working normally.

'Resurs-F' Satellite Launched 27 June

LD2806064789 Moscow TASS International Service in Russian 0546 GMT 28 Jun 89

[Text] Moscow, 28 June (TASS)—The artificial earth satellite "Resurs-F" was launched by a "Soyuz" carrier rocket in the Soviet Union on Tuesday. It is intended for taking multizonal and spectrozonal photographs of varied scale with the aim of continuing the study of the earth's natural resources in the interests of different branches of the USSR's national economy and for international cooperation. The satellite has been placed in orbit with the following parameters: initial period of revolution, 88.7 minutes; apogee 262 km; perigee, 195 km; orbital inclination, 82.6 degrees. The apparatus aboard the satellite is working normally.

'Nadezhda' Navigation Satellite Launched 4 July

LD0507081189 Moscow TASS International Service in Russian 0745 GMT 5 Jul 89

[Text] Moscow, 5 Jul (TASS)—A "Nadezhda" ("Hope") artificial earth satellite was launched in the USSR by means of a "Cosmos" carrier rocket on Tuesday [4 July]. It carries apparatus of a navigation system for determining the location of ships of the USSR merchant navy and fishing fleet, and also apparatus for work in the composition of the international space system for search and rescue of ships and aircraft in distress (KOSPAS-SARSAT).

The satellite has been placed in an orbit with the following parameters:

initial period of revolution, 104.9 minutes;

apogee, 1,026 km;

perigee, 979 km;

orbital inclination, 83 degrees.

The apparatus installed on the satellite is working normally.

'Gorizont' Communications Satellite Launched 6 July

LD0707075189 Moscow TASS International Service in Russian 0730 GMT 7 Jul 89

[Text] Moscow, 7 July (TASS)—In accordance with the program for the development of communications and television relay systems with the use of artificial earth satellites, a regular "Gorizont" communications satellite was launched in the USSR on Thursday [6 July]. It has been put into an almost stationary orbit by a "Proton" carrier rocket with the following initial parameters: distance from the earth's surface—35,100 km; period of revolution around the earth—23 hours, 21 minutes; orbital inclination—1.5 degrees.

The apparatus aboard the satellite is working normally. The operation of the satellite's communications and television apparatus will be carried out in accordance with a scheduled program.

'Resurs-F' Satellite Launched 18 July

LD1907084689 Moscow TASS in English 0818 GMT 19 Jul 89

[Text] Moscow July 19 TASS—The Soyuz booster rocket lifted into orbit on Tuesday a Resurs-F artificial satellite developed in the Foton design bureau at Soviet Glavkosmos. Equipment is installed on board the satellite for various scale multizonal and spectrozonal photographing for purposes of continued research of earth's natural deposits in the interests of different branches of the Soviet economy and international cooperation.

The satellite's orbit has the following parameters: the initial period of revolution - 88.6 minutes, maximum distance from earth - 253 kilometers, minimal distance - 195 kilometers, inclination - 82.6 degrees.

The equipment on board the satellite functions normally.

Data is fed to the state production-and-research center "Priroda" of Glavkosmos for processing and use.

Together with the Resurs-F, two passive detachable satellites of the Pion series have been launched for a study of the density of the upper atmospheric layers. The satellites were developed by a student design bureau at the Kuibyshev Aviation Engineering Institute named after Sergey Korolyov.

'Resurs-F' Satellite Launched 15 August

LD1608065389 Moscow TASS International Service in Russian 0635 GMT 16 Aug 89

[Text] Moscow, 16 Aug (TASS)—On Tuesday a "Soyuz" carrier rocket launched the latest "Resurs-F" artificial earth satellite in the USSR. The satellite was developed by the Foton design bureau of USSR Glavkosmos.

The satellite carries apparatus for the conduct of multizonal and spectrozonal photography on various scales with the aim of continuing research into the Earth's natural resources in the interests of various branches of the USSR national economy and international cooperation.

The satellite has been placed in an orbit with the following parameters: initial period of revolution, 89 minutes; apogee, 258 km; perigee, 192 km; orbital inclination, 82.3 degrees.

The apparatus aboard the satellite is working normally.

Sagdeyev Discusses Reasons for Failure of Phobos Mission

18660200 Moscow PRIRODA in Russian
No 6, Jun 89 pp 3-6

[Article by Academician R. Z. Sagdeyev, Hero of Socialist Labor, Laureate of the Lenin Prize and the State Prize: "To Restore Trust in Our Space Programs". First two paragraphs are introductory paragraphs in source.]

[Text] On March 27, 1989, after a routine session of television pictures of the Martian satellite Phobos, the radio link with the Phobos automatic interplanetary station was interrupted. All attempts to restore the link failed. According to specialists, the probe began to rotate uncontrollably. The temperature on board had dropped to about 0 degrees centigrade by April 8-10, and by April 13-14, it had dropped so much that it became impossible for the instruments to continue operation. On April 14, The Flight Control Center made the decision to discontinue the interplanetary expedition to Phobos [1].

R. Z. Sagdeyev, scientific director of the project, discusses causes of the accident and the results of the portion of the scientific program which had been completed before the second Phobos lost power.

Unfortunately, the mass media's coverage of the flight of Phobos-2 cannot be called an example of the current glasnost. Naturally, a number of questions arise because of this. The public wants detailed and, more importantly, true answers to these questions. On April 15, the leading participants in the project met with journalists in an attempt, a not quite successful one, in my opinion, to provide some explanation.

For example, the representatives of some industrial organizations said that the probe lost power because it collided with an unknown object in orbit around Mars, or attributed the accident to solar flares. I was ashamed to listen to all this. Unfortunately, these explanations got into print, and the statements of colleagues at the USSR Academy of Sciences Institute for Space Research were not very widely reported.

We analyzed the probability of "meteorite danger" for a spacecraft in Martian orbit near Phobos, accounting for four types of possible processes. I can categorically state that the probability of collision with a "large" body (with a mass of no greater than 10 grams) capable of having a serious effect on the flight of the probe in orbit near Phobos is extremely small, about once in a thousand years. The spacecraft was only near Phobos a few days. So this version does not stand up to criticism.

But what actually happened? I think that one of the two providers of Phobos' service equipment was not able to provide a sufficiently reliable design. It is possible that the radio transmitter failed (at that time it was already working on reserve power, since the main source had failed earlier). It is more likely that the on-board computer failed, which is not linked with commands from Earth. When the spacecraft began its routine television photographing of Phobos (there had been such sessions earlier), transmission to Earth ceased, because when the television cameras turned to Phobos, the high-directional antenna which was aimed toward Earth also, naturally, turned away.

By the way, if the Vega spacecraft had been designed the same way in their time, we would never have gotten one picture of the nucleus of Halley's comet. I remember that both Vegas, and later Giotto of the European Space Agency entered the dense gaseous dust cloud at great speeds, and there was no guarantee that they would emerge undamaged by impacts with dust particles. Thus, to "free" the transmitting antenna (which always had to face Earth and give direct reports), a special platform was built which turned the antenna, cameras, and other instruments in the right direction with the right speed. Unfortunately, no such precaution was taken on the Phobos spacecraft. When there was no link with the spacecraft the next time (in about two hours), something had failed. We can now talk only of the probability of some event. I think that the experts will sort it out after the traditional practice of "passing the buck."

But this is not the main thing. Of course, space projects are not insured against failures. For insurance a pair of spacecraft are launched, and each instrument has a blocking system. I think we should seek the cause of the failure in the very organization of the project, in its planning. At least 6-7 years are required to prepare such a complex and unique project (this figure comes from our experience and American experience). It is true that there were periods, especially in the first years of cosmonautics in the early 60s, when many Lunik, Luna, and Lunokhod spacecraft were launched at short intervals. But because of their relative simplicity, the spacecraft did not require such a long preparation time. Today, the technology is much more complex. And after all, the idea isn't to set records for the preparation time of projects, but to create more and more reliable equipment for comprehensive research in space.

I remember December 1984, when we managed under great pressure in a difficult situation to completely test the equipment and systems for the Vega project. All of the preparation for this project took four and a half years, a record! But we were "pressured" by the event itself, the approach of Halley's comet. The most extraordinary measures were taken; for example, we formed an international scientific and technical committee, a group of scientists and engineers, who had great authority to monitor and intervene in everything done in international cooperation, including our industry. Many new technical solutions were found, and here and there we developed alternatives on a competitive basis, for example, for the rotating platform. All of this helped, and there were no losers in this competition.

But of course we knew that it was impossible to work regularly at such a tempo, that time was needed for more detailed checking and testing of equipment, and for choosing the most reliable variants. There were only three and a half years from the launch of the Vegas to the launch of the Phobos probes. The project itself hadn't even been approved! So, we actually built in failure from the very start, at the planning stage.

I sadly remember how at the launch of the Vegas the directors of national space agencies participating in the project, ministers, and the directors of institutes assembled. The first question they asked when they left the plane at the Sheremetyevo airport was "Well, has Phobos been approved?" I experienced a feeling of awkwardness for the great space power that had laid mankind's road into space, launched the first cosmonaut of the planet, and what is more, claimed the first planned economy in the history of civilization. At the gala dinner celebration of the successful launch of the Vegas, instead of traditional congratulations, all the toasts were unexpectedly proposed to the approval of the Phobos project. It was like a psychic attack. Apparently, our leadership could not withstand it, and promised that a decision would soon be made. And what would have happened if this meeting had occurred six months later, when a unilateral moratorium on toasts had been introduced? But seriously, we have lost control over planning in cosmonautics under a pile of routine matters.

Now, after the loss of the second Phobos [2], we possibly should have bitterly reproached our partners from industry. But they also had only the same three and a half years. And I think the most serious conclusions must be drawn from the severe lesson we have learned. Primarily lessons about our space cooperation, and the interrelations within it. Basically, The USSR Academy of Sciences, and specifically, our institute (and a number of others) are the customers for equipment to carry out fundamental research in space. And the contractor, the producer, is space industry, specifically the USSR Ministry of General Machine Building. I am compelled to state the fact that the relationships between the customer and the contractor over long years of work, are clearly abnormal: up until now we could not consider ourselves a full-fledged customer; we were completely dependent on the producer. Economists have thought up a wonderful term, "the dictatorship of the producer," which explains a lot, but unfortunately does not get us out of this dead end. It seems to me that in space research, the dictatorship of the producer, multiplied by its closeness to the military-industrial complex, where glasnost is still slow in arriving, complicates our work. But I certain that the customer should still evaluate the work, and in our case, that is science.

As for the Phobos spacecraft, I am convinced that both of them were lost due to various defects in the design introduced by the general contractor, and more importantly, due to low "survivability." The division head of the USSR Academy of Sciences Institute for Space Research, V. I. Moroz, clearly formulated why the Phobos craft cannot be considered a new generation spacecraft: they have low survivability and low information capacity. The American Voyager probe, launched in 1977, will approach Neptune in August of this year, transmitting 100 kilobytes per second (the Phobos could only transmit 4 kilobytes per second). I think that the numbers are sufficiently eloquent. And references to the poor component base do not help, since Voyager was built 12 years ago.

Now I would like to dwell on the results of the science program. In formulating the goal of the Phobos project, we tried to combine three tasks. First, on the trip to Mars to study solar astrophysics and the physics of the solar system. Then, to study Mars, its atmosphere, and surface. Basically, after the 1975 launch of the American Viking spacecraft, which for several years transmitted very interesting scientific information from the surface of Mars and from orbit around it, the planet remained undisturbed for a long time. But interest in it didn't abate. Thus, the Phobos project provided for the first return to Martian orbit and study of changes which had occurred in the interim both on the surface and in its atmosphere. These two stages of the program were carried out successfully. The information we have obtained is still being processed, but it is already possible to give some results.

The X-ray telescope was used to study the Sun on the way to Mars. On April 27, 1988, strong solar surges were recorded (it turned out that the radiation was completely polarized), and on April 28, a very strong gamma-burst from the sun was recorded. Solar oscillations were also studied, as well as space plasma near Mars. The question of whether Mars has a magnetic field and its strength remains unresolved. The planet apparently has radiation belts, but they are very weak, unstable (they don't last very long), and thus are harmless.

The surface regolith of Mars was studied from orbit. Scanning was done, not in one dimension, but two. As a result, images were obtained in the 2 micron range. These images were used to create a hypsometric map, making it possible to determine the content of rock on the surface.

But of course the quintessence of the project, the part where the most original scientific ideas and decisions were incorporated, should have been the encounter with Phobos. A gamut of experiments were planned, among them laser sounding of the surface. (Our opponents, dreaming of the use of lasers for completely different, hostile goals, called this exotic technology.) There was also a proposal to study the matter of Phobos with an ion beam, and for insurance, to make sure the results were correct, it was also necessary make measurements at different points on the surface, and landers were ready for this. Signals from one of them would have been received by an international Earth network of radio telescopes, and we planned to carry out this work over a period of many months.

We did obtain photographs of Phobos, and even carried out the first studies of its surface. But we had hoped for a closer encounter and a much longer time to work, weeks, and even months.

But it's all finished. Our foreign partners are no less distressed than we are. It should be said that the foreign press has had great understanding: on the front pages of the New York Times, Washington Post, and other leading newspapers were articles stating that this was a serious blow for world science. They expressed the fear that this could be used by opponents of closer political relations with the Soviet Union, opponents of cooperation in space, and in particular, opponents of the commercial use of our space technology proposed by Glavkosmos.

The situation is no better here in our own country. It is no accident that many candidates for People's Deputy easily armed themselves with the demand that if funding for cosmonautics was not completely eliminated, then it should be seriously reduced. Although I do not agree with such subjective appeals, I understand very well why they could raise a claim against our space program. As always, there was a catastrophic shortage of information. Reports of successful launches, dockings, etc. were many, and the public became accustomed to successes. Problems, failures, even tragedies were almost unreported.

And isn't it time to make the space budget public? To report what portion of the total number of launches are purely scientific? Finally, to conduct a national discussion of the planned space programs and complete them in appropriate commissions of the future Supreme Soviet?

When I was a candidate for People's Deputy from the Academy of Sciences, I included in my election program this point: "To renew the trust of the Soviet people in the space program." I think it is necessary to do this through glasnost, through truthful information, and without doing things just for show. The task of our space cooperation is to prove that without space research, mankind has no future. Research is necessary to solve problems in ecology, the national economy, and fundamental science, and still, for a time at least, in the area of defense, for the new thinking has not yet become a part of the flesh and blood of our opponents.

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2. For more on this, see Ne stanovitsya v pozy mladshego partnera! (Intervyu s R. Z. Sagdeyevym) [Don't be a junior partner! (Interview with R. Z. Sagdeyev)]. PRIRODA No 1 1989, pp 33-46.

Maksimov Discusses Military Uses of Space

PM0708112389 Moscow KRASNAYA ZVEZDA in Russian 29 Jul 89 First Edition p 3

[Interview with Colonel General A. Maksimov, USSR Defense Ministry chief specialist on missile and space systems and their development prospects, by Colonel M. Rebrov under the rubric "Portrait in Light of Glasnost": "Logic of Large Numbers"; place, date not given]

[Excerpts] [Passage omitted] [Rebrov] Aleksandr Aleksandrovich, military space expenditure received publicity recently. It was stated to be the considerable sum of R3.9 billion. A considerable figure. KRASNAYA ZVEZDA readers are interested in how these billions are distributed, and for what? What is the logic, as it were, of large numbers?

[Maksimov] Would you like me to break them down?

[Rebrov] Just so. Frankly and in detail.

[Maksimov] Frankness will probably be relative. Quite a lot has been said and written about possible aspects of the use of space technology for military purposes. Artificial earth satellites can fulfill very different functions, including intelligence functions. They are capable of resolving and do resolve tasks of establishing stable radio communications over great distances, which means that they make it possible to control troops at the operational-strategic level and, subsequently, at the tactical level too. Spacecraft make it possible to substantially specify the characteristics of the earth's gravitational field, to make a geodesic survey of continents and individual objects, to create a unified world geodesic network.... Navigational satellites are needed to determine the precise location of ships, aircraft, and other mobile means of transportation. Specialized satellites make meteorological and hydrodynamic observations with a view to enhance the operational effectiveness and accuracy of weather forecasts in particular regions, as well as determining the nature of the ice situation. Space technical means have been developed in these and other areas and have specialized in individual tasks with a view to enhance the accuracy and volumes of information obtained and passed on....

[Rebrov] Not only does the military need satellites for navigation, weather forecasting, cartography, rescue...

[Maksimov] Yes, that is so. If you turn to history, you can find a great number of examples where military affairs have made use of the latest achievements of natural science and technology for their own purposes. Past wars show that the use of new means of struggle has given a decisive advantage to the side which mastered them first and used them on the battlefield.... Let us recall Engels. He wrote: "Nothing so depends on economic conditions as the Army and Navy. Armament, makeup, organization, tactics, and strategy depend, above all, on the degree of production reached at that

moment and on the means of communication." Cosmonautics is no exception in this sense.

[Rebrov] Consequently, space technology can become a combat weapon?

[Maksimov] It can. And a very formidable weapon. The Soviet Union has opposed and is opposed to the militarization of outer space. The fact that the arms race in space will cost mankind hundreds and thousands times more than the rivalry in missiles and nuclear weapons is not at issue here. The "star wars" idea harbors a danger to all terrestrial civilization and poses a real threat of a space apocalypse. Judge for yourself: The United States intends to create [sozdat] by the mid-nineties a system designed to hit spacecraft from the sea and from land. Like weapons for destroying ballistic missiles, the ASAT antisatellite system is one component of the militarization of space, which the Pentagon is carrying out within the framework of the "star wars" program. Such a system, if commissioned, will do great harm to international security and the atmosphere of trust and hinder the peaceful research and use of space. I will add: The satellites for which the Pentagon intends to hunt include ones which pass on important information on the location of weapons systems and troop subunits and which are an effective means of verifying observance of the treaties concluded on arms limitation and disarmament. In August 1983 the Soviet Union announced a unilateral moratorium on ASAT-type weapons and intends to adhere to it as long as other states display prudence.

[Rebrov] You said "as long as." Yet it is no secret today that the United States would like to let the "space genie" out of its laboratories as quickly as possible in order to acquire military superiority.

[Maksimov] Unfortunately, this is so. In addition to the ASAT system, the United States is carrying out a great volume of work on creating [sozdaniye] various types of space weapons based on new physical principles. It is a question of using particle accelerators, lasers, microwave radiation, and so forth. The United States is trying to circumvent the ABM Treaty by means of all kinds of verbal subterfuges and, essentially, to wreck this and other agreements. Proof of this is provided by its desire to put strike combat means into orbit. Tests in space of a generator and emitter of neutral particles and of various laser systems and the project with the exotic title "smart rocks"—all this pursues quite definite ends. This work is still at the research stage, but we must give it a definite evaluation right now.

It should be said that the position of the military department is increasingly being criticized in the United States itself. Experts warn that the continued militarization of space could negate the Soviet-U.S. disarmament effort and threatens the country's national security.

[Rebrov] How is this to be understood?

[Maksimov] The arms race is called a race because it pushes the opposing side into creating analogous means, as well as antisystems which are more powerful and more compact. This in turn gives rise to the desire to do something still more effective. A chain reaction begins.

[Rebrov] Another amplification. Your words could be taken to mean that we will be forced to create [sozdavat] our own SDI.

[Maksimov] I would like our conversation to take place along the lines of logic, not guesses. And logic is such—incidentally, Mikhail Sergeyevich Gorbachev has spoken of this—as to find the most inexpensive and most simple means of making SDI ineffective and pointless.

[Rebrov] Let us return to the areas of the military use of space technology which you named. How is reconnaissance from space to be coordinated with legal norms?

[Maksimov] International law does not prohibit spacecraft from overflying foreign territories. Regarding the SALT II Treaty, it directly provides for the use of national means to verify observance of international accords.

Some specialists in the West use the term "covert glasnost on a world scale." It is invested with this meaning: We have been living without war for more than 4 decades because we look intently at each other from space.

[Rebrov] Is this a relevant question: What potential does space technology have for resolving these tasks?

[Maksimov] Perfectly relevant. Space reconnaissance makes it possible to obtain an image in the visible spectrum with resolution down to 0.2-0.3 meters. This means that from orbit it is possible to see every player on a soccer pitch, to determine whether a bomber of the B-1 type is equipped with missiles... Radiotechnical reconnaissance makes it possible to locate radiation in practically all bands and to determine the coordinates of the source of this radiation.

This is one aspect of the matter. The second aspect is that space reconnaissance makes it possible to intercept radio conversations. With the help of retransmitter satellites all this information can be obtained in close to real time. From space it is possible to keep track of missile launchers and issue a timely early warning of a possible attack.

[Rebrov] Information of this kind will be of value only if there is permanent observation.

[Maksimov] Naturally. It is necessary to "watch" continuously, every minute. For this it is necessary to have several special satellites and to replace them as their operating life comes to an end.

[Rebrov] This increases the cost of information.

[Maksimov] Yes. But are you not prepared to pay any price to know in good time about an attack that is being

prepared? Hence another figure: According to calculations by USSR Defense Ministry specialists, the implementation of military space programs alone will enhance our Armed Forces' combat efficiency 50-100 percent. The role of national space reconnaissance means increases particularly with the adoption of a defensive doctrine.

[Rebrov] Please describe in greater detail the economic effectiveness of other spacecraft used in the interests of the military department.

[Maksimov] I have already spoken of long-distance communications systems. Several dozen apparatuses are in various orbits today, ensuring telephone, telegraphic, facsimile, and other kinds of communication, as well as satellites used to retransmit very diverse information. The saving as a result of using these means may be estimated conditionally at R1.5 billion a year.

The selection of the optimum routes for surface ships, submarines, auxiliary vessels, and aircraft is of tremendous significance, including economic significance. And satellite navigation systems make it possible to achieve high accuracy here. Moving objects use them to determine their coordinates within an error of tens of meters. Following the most advantageous routes makes it possible to save up to R500 million. I could continue and say that space technology is irreplaceable today for drawing up topographic maps.

Certain sums are spent on operating our three cosmodromes, ground measuring centers, computer coordinating centers, communications complexes... These technical means are used by the USSR Academy of Sciences, Intercosmos, Glavkosmos (Main Administration for the Creation and Utilization of Space Technology), the "Priroda" State Center... These, briefly, are the classes of expenditure. Such, as you said, is the logic of big figures. [Passage omitted]

Party Secretary Baklanov Defends Space Program

LD1805215789 Moscow TASS in English 1739 GMT 18 May 89

[Text] Penza May 18 TASS—In implementing Soviet space programs, we proceed from the following principle: All progressive accomplishments, tested and introduced in space technology, should be used in the national economy, a senior Soviet Communist Party official has pointed out.

Oleg Baklanov, secretary of the party Central Committee, addressed party activists in Penza, central Russia, on Wednesday [17 May] at a regional meeting that discussed tasks of raising living standards.

The Central Committee secretary defended the space program in connection with the widespread criticism that space research fails to bring benefits to the national economy.

He said that the development of the Energiya-Buran system alone helped produce more than 80 types of new materials. Their use in the national economy sharply increases the reliability and service life of many machines and mechanisms, he observed.

About 300 specific scientific and production tasks are being handled with the use of materials produced thanks to space research. Baklanov also revealed that the economic effect of space photography alone is approaching one billion roubles a year.

Speaking about conversion, the Central Committee secretary said that it will make it possible to increase consumer goods production by 1.4 times in the next year.

"This powerful potential is being tapped thanks to the persistent and active peaceful foreign policy of the party and the Soviet State, of which Mikhail Gorbachev's recent visit to China is fresh and convincing evidence," he remarked.

Doguzhiyev Discusses Costs, Economic Benefits of Energiya-Buran System

18660182 Moscow PRAVITELSTVENNYY VESTNIK in Russian No 11, May 89 pp 2-3

[Article by V. Kh. Doguzhiyev, USSR Minister of General Machine Building, under the rubric "Examined in the Presidium of the USSR Council of Ministers: Space: Outlays and Returns"; first two paragraphs are introductory paragraphs in source; next three paragraphs—italicized, under subhead "Some Information"—make up informational sidebar inserted by the newspaper's editorial staff]

[Text] **"Why was so much money invested in the Energiya-Buran system? Especially with our budget deficit!" These questions are encountered in letters to the editorial office. "We're getting ready to fly to Mars, and the stores are completely empty." The readers are indignant. Demands to decrease expenditures on space projects and research are contained in the programs of several People's Deputies, and this position has a definite group of supporters.**

Meanwhile, the space program has already provided a solid return by generating qualitatively new and economically effective solutions in communications and television, in meteorology and geodesy, and the study of the natural resources of the Earth and oceans. The economic impact from space photographs alone, photographs which contain valuable information for fishermen and geologists, foresters and farmers, is about a billion rubles a year. But ever newer ways are being found to use space technology in the interests of mankind. Even to create this technology it was necessary to identify and concentrate the best scientific and technical achievements of the country, which serves as a powerful stimulus to the acceleration of progress. Naturally, space technology should share its potential with the entire national economy. So that this

mechanism of implementing innovations can act smoothly and precisely, the Presidium of the USSR Soviet of Ministers examined the question of using the scientific and technical achievements obtained in the creation of the reusable Energiya-Buran spacecraft system in the national economy. At the request of the editorial office, USSR Minister of General Machine Building V. Kh. Doguzhiyev discusses what this extremely complicated technical system is giving to the national economy, and how it will return the funds invested in its creation.

Some Information

The Energiya-Buran reusable space system was designed to carry out specific tasks, scientific and applied research, and experiments in the interests of the national economy, science, and defense, as well as to place space vehicles, cosmonauts, and payloads into orbit, service them there, and return them from orbit to Earth. The decision to create a domestic reusable space system was made in 1976, when the US had already done much work on the space shuttle. Our lag behind the US consisted not only in the four-year delay before the decision to begin funding was made, but also in our considerably smaller stockpile of scientific-and-technical and production components.

While the the reusable space system was being developed, the most powerful liquid-fuel rocket engines were also being developed—including those that used a fuel (oxygen and hydrogen) that we knew little about—plus high-performance computer complexes for ground-based and on-board systems, new materials and coatings, and an experimental production base. In the United States, these problems, for the most part, had already been solved in the creation of the Saturn V-Apollo complex.

We did not copy the American space shuttle. Here are the fundamental conceptual differences. Our reusable space system consists of two independent units—the Energiya launch vehicle, which is capable of lifting a payload of up to 105 tons into orbit, and the Buran orbiter. The space shuttle has no launch vehicle (the engines are on the orbiter, and the core unit is an external tank). Buran can perform the entire flight program and landing in automated (unmanned) and manned modes. The shuttle orbiter can be operated in manned mode only. The Energiya-Buran system uses ecologically clean, high-energy liquids—mainly, cryogenic fuels (oxygen, hydrogen, and kerosene). The space shuttle, on its first stage, uses solid rocket boosters. In terms of its destructive effect on the ozone layer, one launch of the space shuttle system is equivalent to several thousand launches of the Energiya-Buran system.

The public's interest in the reusable Energiya-Buran spacecraft system is understandable. It is not idle curiosity. It represents a businesslike, economic, and, I would say, proprietary approach. The question of the return is entirely natural. We estimate that the expected economic impact on the national economy of the use of the reusable Energiya-Buran space system and of the scientific and technical advances produced in its creation will be 4-5 billion rubles a year. That will make it possible to gradually offset our expenditures for the creation of the system, which over 13 years amounted to 14 billion rubles.

By a decree of the Central Committee of the CPSU and the USSR Council of Ministers, an enormous amount of scientific-and-technical, industrial, and construction manpower was enlisted from all across the country to build the Energiya-Buran system. There was effective cooperation between enterprises and sectors, on the one hand, and a powerful intellectual and production potential, on the other.

What are the basic areas of application of this system in the national economy. There are plans to use the Energiya-Buran system to service in orbit optoelectronic and radar reconnaissance satellites. That would make it possible to increase the active lifetime of these unique vehicles to 5-7 years or more, from 2-3, that is, it would actually cut down on our expenditures to produce them. The reusable system will make it possible not only to place heavy and expensive vehicles in orbit, but also to check how they're working just before they're released from the orbiter, as it's done with the Lacrosse and Magellan satellites in the United States. If necessary, problems could be fixed or the vehicles could be returned to Earth for repair. The losses prevented amount to the hundreds of millions of rubles which the satellites cost (the Lacrosse satellite, which was recently released in this way from the American space shuttle, cost about 500 million dollars). Moreover, this represents 5-7 years of work by collectives at hundreds of enterprises and organizations.

The use of the reusable system is also economically vindicated in the context of the creation and servicing of Mir type orbital manned complexes. And in the event of accidents aboard orbital stations or transport spacecraft, Buran would be a reliable means of rescuing their crews.

Several of the leading countries of the world—the United States, France, FRG, and Japan—are now creating the Freedom orbital station. One of its main purposes is the production in space of semiconductor materials, biological preparations, and optical glass. The specialists of these countries think that the materials produced in space will pay for the station in 2-3 years.

On the Mir orbital complex, on biosatellites, and on the Foton space vehicles, we are also perfecting the technology for producing such materials. Encouraging results have been obtained in the production of unique semiconductor materials and alloys, as well as biologically active substances for the yeast production of super-pure, highly-effective medicinal preparations. Energiya-Buran is helping us to retain our position among the leaders here. Two alternatives are being studied: to either transform one of the Buran spacecraft into an automated plant for space production, or use the reusable system to create a new-generation manned orbital complex whose

tasks would include, among other things, space production. It would take 7-8 launches of the reusable space system, including 2-3 launches of the Energiya booster, to lift into orbit all the base and functional units. By comparison, it will take 20 launches for the American space shuttle to build Freedom. Solving this problem with disposable launch vehicles would be 1.6 times more expensive.

There is a world trend toward expansion of work on launch vehicles and the creation of space transport systems that include disposable vehicles as well as reusable transport vehicles. For example, the United States has begun study of a heavy-duty, reusable, unmanned vehicle that is called "Shuttle-C" and is based on the components of the space shuttle system. In this case, instead of a manned orbital stage there would be a disposable cargo container. We already have such a vehicle—Energiya. It is true, however, that it is still not fully reusable.

The Energiya booster rocket, with a cargo platform instead of an orbiter, is capable of placing into geosynchronous orbit a group of vehicles or a large, heavy-duty vehicle weighing 4-20 tons. They can be low-orbit or high-orbit platforms for reconnaissance, communications, television, ecological monitoring, and space production. This task can't carried out by other means.

There is also the possibility of handling inter-city telephony and direct, high-quality television broadcasting. Now only about 20 percent of the country's population has telephones, and there is essentially no reliable branch telephone service between population centers. Orbita communications satellites are not suitable, because of their insufficient power and information capacities. Moreover, such service cannot be achieved by laying underground or above-ground communication lines. In the meantime, experience gained in creating and using the Mir orbital station has made it possible to create in the next few years a universal orbital platform weighing up to 18 tons (the present communication satellite, Gorizont, weighs 2.5 tons) It will be placed in geosynchronous orbit by Energiya. Such a platform can hold the appropriate equipment and power-supply sources. A group of four such platforms could serve 480,000 users simultaneously—that is, in essence, solve the problem of inter-city and international communications without laying additional trunk lines. International cooperation in the creation of such a system is completely realistic.

As you can see, a reusable space system can provide a solid return. Another side of the story is the use in the national economy of advances made in creation of the system. For that we put together and published an album called "The Scientific and Technical Advances of the Energiya-Buran System for the National Economy." This album, which was sent to all ministries and departments, contains 600 original scientific and technical advances: new technologies and materials, machines and devices, programs and methods, experimental installations, measurement equipment, and automated control systems. All of this huge, multisector, scientific and technical surplus is being transferred to the national economy. Many developments have been tested and assimilated in various sectors of production.

The areas of use are diverse and even unexpected. What's the link, for example, between rocket engines and the quality of sausage? It is, in fact, the high-strength stainless steel that was specially created for the second-stage engine of Energiya, a steel that is used for the manufacture of knives and equipment used in the preparation of meat. It increased their strength by a factor of 2-3, improved the quality of the sausage, and increased product output. The specialists at the Moscow Meat Combine are convinced of the merits of knives made according to a "space recipe." These same knives have been sent to enterprises in Shchelkov and Cherkizov. There's another important gain here: we can completely discontinue the import of such knives from the Federal Republic of Germany, which means a savings of more than 10 million in foreign currency rubles.

Fire-resistant fiberglass made from a Buran "recipe" is beginning to be used in the finish work of subway cars. This ensures the safety of passengers in emergency situations. And using polymer composite materials for making equipment and containers for storing and transporting food products saves stainless steel and makes the products last longer. It is calculated that every ton of such material can save about 17,000 rubles.

There is definite interest in the use of ceramics as parts in "terrestrial" water shut-off valve assemblies. Together with the enterprises of the Moscow city ispolkom and the USSR Ministry of Installation and Special Construction Work, we have developed a design for such assemblies with ceramic parts, and preparations are under way for their production. The use of such assemblies reduces water loss by 20-30 cubic meters a year per faucet. This is equivalent to an annual savings of 600-800 million rubles for the entire country.

The as yet meager experience of the USSR Ministry of Health with prostheses and bone inserts that we made from carbon-carbon composite material holds promise for a substantial reduction—by several factors—in the treatment time of patients with compound fractures and traumas. Medical personnel are also interested in the technology of precision casting with special alloys. Such technology could be used to create arm prostheses from cast titanium. The first batch of these goods are already being tested. And special tungsten alloys will be used to produce heavy-duty prostheses to replace bone joints.

There are 20,000 pipe joints on the Energiya vehicle. The quality of the welds must be guaranteed. We did that by employing special welding heads in our automatic welding of non-swiveling joints. Now this technology is being used in welding the pipes of equipment used to process milk and refine sugar. It is indispensible in the petroleum industry and in the area of nuclear power engineering.

Soldering—primarily with silver-based solders—is widely used in the manufacture of the liquid-fuel rocket engines. We discovered how to solder without silver. As a result, in the mass production of compressors for household refrigerators, two tons of silver will be saved at one Mazheykskiy plant alone, where the yearly program for the manufacture of compressors involves one million pieces.

Providing a good seal that is commensurate with molecular layers in grade is a very important requirement for spacecraft equipment. A new device that used cold plasma to detect gas molecules using cold plasma was created. That technology has already found wide application in the national economy, in particular, in the testing of household refrigerators, various vessels, and the gas cylinder systems of automobiles.

Of principal importance in assuring the reliability of Buran's systems was the mastering of the technology involving high-precision casting with high-temperature alloys. Now this method has been successfully implemented in the production of valve bodies and pump casings used in the milk industry. The use of this method is being developed for the manufacture of parts for kneading and for dies used to make picture tubes, which eliminates the need to import this equipment from Japan at 2.5 million foreign currency rubles a year.

The problem of the ecology of production shops, especially foundry and heat treatment shops, is becoming severe. There is, therefore, an urgent need for the transfer into the national economy of an ecologically clean process for nonferrous casting into molds made of magnetically-soft material—barium ferrite—instead of molding sands and and ecologically clean process for heat treatment in organic quenching media instead of oil.

For the experimental development and testing of the parts, units, and assemblies of the Energiya-Buran system, a state-of-the-art base was created. The complex of unique, durable test stands makes it possible to study the static, dynamic, impact, and vibration strength of large structures under conditions that include high and cryogenic temperatures. The USSR Ministry of General Machine Building suggests that all sectors of industry use the rich possibilities of this base. At their service is a large set of state-of-the-art measuring devices which make it possible to automatically process the results of measurements. There is also an extensive bank of methods and programs necessary for the study of the condition of the structural elements of any machine or mechanism.

Extremely complex, integrated simulation units that were developed to study the processes associated with the control and stabilization of the Energiya-Buran system can be successfully used in the national economy to create, for example, unique automatic control systems for power engineering and chemical production.

Testing of the reusable Energiya-Buran space system is not yet finished, but it is already beginning to work for the national economy and provide a financial return.

Semenov Discusses 'Mir' Program Costs, Shuttle Plans

18660181 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 30 May 89 p 4

[Interview with Yu. Semenov, chief spacecraft and space station designer and corresponding member of the USSR Academy of Scienecs, by G. Lomanov; date, place not specified: "Where Is Buran Flying"; first paragraph is editorial introduction]

[Text] Just a few years ago, perhaps even last year, such a conversation would have been unthinkable. Newspapers described original technological solutions and unique experiments in orbit. It was not acceptable to discuss the economic aspects of space science, even less so to compare efficacy with expenditures. The mist of departmental secrecy is dissipating, and space science has learned to count its pennies.

[Lomanov] Yuriy Pavlovich, most of our readers understand the advantage of communications and weather satellites. But the Buran program, as a rule, is sharply criticized; in a polemical volley, readers refer to expeditions to the Mir station as excursions which do the national economy no good. Is this the case?

[Semenov] Well, shall we begin with Mir? We began the development of a modular-type station in 1976. We have spent R1.7 billion on the entire program over 13 years. This includes everything from the first diagrams to the manufacture of stations, delivery systems, and spacecraft, from scientific equipment to housing for people working in our branch. In the early years, of course, the expenses were low; the lion's share came with the period of Mir operation. Approximately 200 scientific, planning, and construction organizations of 20 ministries and departments participated in the program. Incidentally, now after Buran, the scale of this unseen cooperation already seems modest: 1,200 organizations worked on the creation of the space "shuttle."

The scientific-experimental program on Mir is developing in 6 fundamental directions: improvement of space technology itself, astrophysics, study of natural resources, technology, biotechnology, medicine and biology.

[Lomanov] I wonder how expenses are allocated; what is given preference?

[Semenov] Most, almost half a billion, was spent on modernization of space equipment. Incidentally, in creating equipment we take into consideration the issues of economic efficacy. For example, gyrodynes allow for the orientation of the space complex without wasting fuel. A new life support system spares us the need to constantly bring oxygen regenerators on board. Because of this, we

can deliver a supplemental 24 metric tons of cargo to Mir, mostly scientific equipment. This approach reduces expenses.

Approximately 270 million goes to astrophysical research. These expenses are not small, but they can be explained. They include research and development of the unique Kvant module. On the other hand, the results obtained on the orbital observatory are unique; this is the opinion not only of our own, but of foreign scientists as well. And in last place we have biotechnology experiments which cost 3 million; you know that we began to develop this trend recently. All this adds up to about 1 billion.

[Lomanov] The remainder is over 700 million. Which column do we put it in?

[Semenov] I would call it long-range research and development; for example, a mechanism which allows the cosmonaut to glide freely in open space, an autonomous platform with scientific apparatus which a crew or operator on earth can aim at an object of interest to scientists. But first and foremost, this money went toward the creation of modules.

[Lomanov] About which we have already been talking for 3 years, since the launch of Mir, but there are still none of them.

[Semonov] Work on the first module was proceeding normally; it is now at the Cosmodrome. But if we attach only one, the complex of space apparatus will look like the upside down letter "L," and such a configuration is inconvenient for orientation. Symmetry is necessary, even of the type seen in the letter "T." Therefore, the gap between the mooring of both modules must not be more than 2-3 months. Alas, something did not go right with the second one, and frankly, the preparations to launch Buran took a great deal of effort. This module is now ready as well and will undergo testing on the control-experimental test stand. We plan to launch the first module in the September-October period, and the second, technological one in December or January of next year.

[Lomanov] Let's return to bookkeeping. We have broken down the expenses in general terms. But what are the revenues?

[Semenov] I'm not going to enumerate everything that Mir has done over the 3 years of its operation; much has been written on the most significant experiments. I will cite just one figure: Over this time about 5,000 experimental sessions were conducted on board. The economic effect is in the range of R300-400 million.

[Lomanov] From whom was this received? And what kind of economy is this, actual or potential, as before?

[Semenov] Unfortunately, for the time being, this is potential; before the new economic trends, no one practiced mutual accounting as space programs were being realized. For example, various branches use satellite communications systems even though they did not finance them and they did not reimburse the "space department" for their expenses. One more illustration—orbital photography revealed that there is half again as much suitable grazing land in Tajikistan as had been registered. How much would this review have cost had it been done by overland methods? Name a figure, the effect will be conditional, even though the benefit to the national economy is beyond doubt. Such an approach was formulated in the period when space science received funds from the budget and its achievements were used gratis by disparate branches from medicine to forestry, from fishing to electronics. The time of reckoning has come.

[Lomanov] Whether accounting methods are good or bad, whether we speak of potential or real contributions, all the same, the bottom line does not favor manned flights—expenditures are almost five times higher than the returns from research on Mir.

[Semenov] The station will continue to operate for several more years. The arrival of the module, I would remind you, will make possible the broader development of pure and applied research and the recovery of the R1.7 billion spent over the course of 13 years. Incidentally, this figure is not as high as it seems to some. Compare the Skylab station, which cost the Americans $2.5 billion, and the $25-30 billion to be invested in the Freedom station, which the United States intends to create from components put into orbit by the Shuttle.

[Lomanov] I'm sure that readers will object to that argument: Only a rich country can spend enormous resources on space science, but here we have empty store counters. I am certain because this is constantly encountered in the letters to the editor. As is the question: Why do we need Buran? The goals achieved by this truly marvelous machine are still unseen. Aren't we being dragged into a senseless and wasteful race?

[Semenov] Either sausages or spacecraft and stations—I can't accept such an alternative. It is not just fine words when we say that space serves the earth. Under conditions of weightlessness, we form expensive crystals of quality the likes of which you could never get under earth conditions. The quality production output is over 90 percent, incalculably higher than with ground technology. The unequaled "space" crystals allowed the creation of a laser television screen of 10 square meters. In the technology module, it will be possible annually to grow about a centner of unique semiconductors. True, industry needs tons. Therefore, we are now thinking about turning one of the Burans into a factory functioning on the watch method: lift off, a month of work in automatic mode, landing with the prepared products, and the next launch.

This is an example of direct benefit. But there is an indirect benefit from the transfer of advanced materials, designs, and technologies. Your newspaper described several of these in an 18 May selection "News of Science

and Technology." Of course, not all of them; about 600 innovations were born with the creation of Buran.

We have grouped them in 10 "packages" and informed dozens of branches of the national economy. About R14 billion has been spent on the entire Buran program starting with 1975. And the introduction of the construction materials recently created for the "shuttle," by modest estimates, will yield about R1 billion. Just one package! So is it fair to consider space science a "dependent" of the state budget?

If matters were correctly set up, the space programs would pay for themselves with interest. I cite a well-known fact: After spending $25 billion on the moon program, the United States earned $75 billion from industrial applications of technologies created for Apollo. Another thing is that we clearly have not yet mastered computing and innovations make their way into production with difficulty. But these are problems of our economic mechanism, our common misfortune. Is space science to blame here?

[Lomanov] Apparently not. On the other hand, it is gratifying that its representatives aspire to greater openness and are not afraid to get involved in commerce. Transfer of technologies is a fine thing, but they are not the reason Buran was created. How is the craft itself supposed to be used?

[Semenov] The chief mission of this unique craft is to put into orbit equally unique and expensive space devices. For example, on their shuttle, the Americans put into orbit a powerful radar apparatus costing half a billion dollars. They supported it in open space with a manipulator for 10 hours, checked it thoroughly, and only then released it for independent navigation. And now imagine: What if they had launched such a device with an expendable booster and it didn't work? Enormous funds would have been spent for nothing. But-...there is no going back. Buran can both deliver into orbit and return from orbit an expensive satellite, bring it to earth for repair, and launch it again. The space "shuttle" will allow repairs and preventive maintenance to be done right in orbit; for example, replacing a power plant on a satellite.

[Lomanov] Satellites almost never fly at an altitude of 350 kilometers.

[Semenov] The maximum ceiling of Buran is three times higher, although, of course, at 1,000 kilometers above the earth, a craft delivers less usable cargo. Therefore, for higher orbits, particularly for a geostationary orbit at an altitude of 36,000 kilometers, interorbital tugs are needed, powered by solar energy, nuclear or hydrogen fuel. The tug lowers the satellite into a service orbit for Buran or an orbital station, and returns it to orbit after preventive maintenance. In a word, a complex space transport system is needed, and Buran will become one of its elements.

[Lomanov] You wish to say that the space "shuttle" is ahead of its time?

[Semenov] To some extent. Although I will note there is hardly any point in speaking of the "shuttle" separately; it would be more correct to consider the possibilities of the Energiya-Buran system. After all, the new powerful delivery system can put not only Buran, but any 100-metric-ton device into orbit. In the near future, we will participate in the telephonization of the country. This is where the advantages of Buran will make their mark. A number of current satellite-retransmitters working in a geostationary orbit do not exceed 2.5 metric tons, of which only about 700 kilograms is actually equipment. Energiya, with its booster assembly, is capable of putting an 18-metric-ton device holding 9 metric tons of instrumentation into geostationary orbit. This is an entire telephone exchange with a mighty power system ensuring simultaneous conversations for almost a half-million subscribers.

The space portion of the system will cost about R2 billion, the ground portion, no less. The total is R4 billion. On the expensive side? You think that ground retransmitters or cables would cost less? Hardly. Calculations show that even if intercity phone rates are lowered, the space system will pay for itself in full within 3-4 years.

The United States plans about 20 shuttle flights for the assembly of the Freedom station. And it is not by accident that interest is being showed in Energiya, which can "carry" 100 metric tons at once. One Energiya launch is about the same as five shuttle flights, each of which costs $170-200 million.

[Lomanov] So, we wish space science a more active role in the domestic and foreign markets. We want to believe that economic thinking will predominate over considerations of prestige, and that the new programs will make headway after open discussion of all the "pros" and "cons." One last question, Yuriy Pavlovich, which will probably interest our readers. When will the next flight of Buran take place; what is its program?

[Semenov] We plan an automatic flight without a crew. The machine which will be displayed at Le Bourget will not be the one to go into orbit. It will be a new one, equipped with a docking unit and a manipulator. The goal is interaction with the Mir station or the Soyuz ship and the development of elements of a system for cosmonaut rescue. The schedule is no earlier than 1991.

[Lomanov] The Americans fly more often...

[Semenov] Of necessity. They emphasized only the "shuttle," and they understand that they made a mistake and are now actively developing one-time delivery systems. We have the famous "number seven," which puts into orbit manned and cargo craft; there is the "Zenit" with a 14-metric ton cargo capacity, the Proton capable of lifting 20 metric tons, and, finally, the mighty Energiya. In a word, a good arsenal of delivery systems

with whose help a number of tasks can be resolved. In general, 5-6 more launches are needed to complete the flight design tests of Buran, although we will also be solving practical problems in these flights.

Shatalov Urges U.S.-Style Space Agency for USSR

PM1905114789 Moscow IZVESTIYA in Russian 18 May 89 Morning Edition p 4

[Interview with Lieutenant General V.A. Shatalov, chief of the Cosmonaut Training Center, by scientific observer B. Konovalov: "Cosmonautics at the Crossroads"; place, date of interview not given]

[Text] [Konovalov] Vladimir Aleksandrovich, many people believe that our cosmonautics suffers very seriously from lack of departmental coordination. Nowadays one set of organizations deals with equipment, another deals with scientific research, and the application of this research is the responsibility of such a multitude of organizations that it is impossible to figure out who is responsible for what. In practice we don't have a single "overlord." Don't you think that it's time for us to create a proper USSR Main Administration for the Creation and Utilization of Space Technology which should be the main organ in cosmonautics not just in name but actually in reality? It has become universally accepted practice to set up agencies which receive appropriations for cosmonautics, act as contracting clients for equipment and research, and enter into economically accountable relations with all users of space information. Could it be worthwhile to take the same path?

[Shatalov] This is not a new idea, and it has been discussed among cosmonauts on many occasions over the years. Our country chose its own path for managing the development of cosmonautics, proceeding from the prevailing departmental structure. Indeed, we do not have an organization like, for example, NASA (the National Aeronautics and Space Administration) which, having brought competent people together, was in a position to set strategic and tactical objectives in space exploration, substantiate the expediency of financing various works, put projects out to competitive tender, competently evaluate tenders, choose the best one, and implement it once more on a contractual basis.

It cannot be said that we have nothing like it. Certain elements are present. But we do lack an overall, well-organized, and permanently operating system. And this, of course, is not beneficial for cosmonautics.

Back in the late sixties, following V.M. Komarov's death, we raised this issue with great urgency. We got as high as D.F. Ustinov (and that was very high indeed at the time). We were told more or less this: "You look after your own business. Your duty is to fly. You know nothing, we set up a USSR Council of Ministers State Commission for the Management of Cosmonautics long before NASA."

Hardly anything has changed in essence since then, despite repeated attempts by different people to introduce improvements.

We are already tired of telling people that we need a substantiated long-term program for cosmonautics. Back in the past this was the province of an interdepartmental scientific and technical council led by Academician M.V. Keldysh, president of the USSR Academy of Sciences. This council is now headed by Academician G.I. Marchuk, but we are still waiting for results from its work.

As the ones who have to do the job, we should preselect the people for specific programs, train them, and place orders for simulators which nobody is likely to produce in a hurry. But we have no programs. Today I have no idea what we will have to do tomorrow or the day after. And even the current tasks are changing all the time.

There we were, having trained two crews for a scheduled expedition to the "Mir" Station. Then we had to stand down. Now these crews have to undergo further instruction and be trained to work with additional instrumentation modules [modul doosnashcheniya] which will eventually be docked onto "Mir." But we still have no program for specific training for, say, next year, never mind the more distant future. We have no consistency in the training of foreign cosmonauts. Obviously the organizations producing instruments to be used on the station have no idea about these plans. We are in no position to familiarize ourselves with these instruments in advance and to evaluate the convenience of their operation from the cosmonaut's point of view. Every time it is a case of "all hands to the pumps."

In my view, our cosmonautics has a vital need for an effective and competent staff [shtab]. There is obviously no need to invent the wheel. World experience is available and, on the basis of this experience, we must set up a space agency of the Soviet Union. It should operate in conditions of total financial glasnost. Priorities should be set with the scientific community's help. After all, we do have earthly problems which are more important than space problems. But I feel that it is irresponsible to talk about it being necessary to halt the development of cosmonautics altogether. We did not invest considerable funds in this sphere for year after year only to "let everything slide" now. Let us bear in mind that a special space council for the pursuit of a national space policy is now being set up under the U.S. President, to be headed by the country's vice president.

[Konovalov] Obviously the paramount duty of the space agency will have to be the organization of national economic work to recoup the cost of manned flights. Hitherto the country has been fed almost nothing but promises. This cannot go on indefinitely....

[Shatalov] Yes indeed, all the numerous stages through which we have gone so far have been, to all intents and purposes, preparations for the creation of space production units. The same thing happens on earth: First you dig a ditch, then you lay foundations, construct walls and

roofs, install lights, water supply, elevators.... In my view, now we have all we need to produce extensive practical returns. It has so happened that this stage has coincided in time with restructuring. But even without restructuring, it is objectively time to embark on extensive practical work in space. The scientific quest stages have dragged on for too long.

The uninterrupted work by crews on the "Mir" Station has proved that cosmonauts can live and work efficiently in orbit for up to 1 year. Supplies are sufficiently reliable, and the station's refueling has been worked out. We have already determined specific spheres in which it would be economically advantageous to set up production units in space. These are primarily the growing of semiconductor crystals for the electronic industry and the production of high-purity medical compounds. There is the energy problem, but specialists believe that it can be solved with the help of additional instrumentation modules and further improvement of solar panels.

The absence of a real "overlord" in cosmonautics has brought about a situation whereby virtually all responsibility for its future is borne by the developers [sozdatel] of space technology. But their main efforts are concentrated on the endless improvement of technology. The USSR Academy of Sciences and other departments are not concerned about returns from technology. This is not right. Now we have all we need to embark on extensive practical work in space. All that needs to be done is to change priorities and set up an organization which would take into account both the expenditure on and the revenue from cosmonautics.

[Konovalov] But all the hopes for starting up production activity are associated with the docking of additional instrumentation modules onto the "Mir" station. Unfortunately, we have been waiting for this for more than 3 years already. At the very beginning, designers praised this station and talked about a "new generation" station whose main distinguishing feature would be six docking units. And yet only two of them are operational, just as it was with previous stations. We would probably use the vilest abuse against people who spend 3 years to bring a new plant up to its design capacity, but here we are keeping bashfully silent. The outcome is that the placement of a new station in orbit was reported to the 27th CPSU Congress, and we have spent 3 years bringing it "up to scratch."

[Shatalov] Correct. Here we are talking about a "space construction schedule overrun." Crews have spent all these 3 years taking additional instrumentation to the station in orbit and delivering equipment there. Many instruments are "half-finished"—50 percent of the scientific equipment does not function. Crews spend too much time on technical maintenance work. Of course, now we have had practical proof that cosmonauts can be assigned any task—either inside the station or outside, in open space—and they will cope with it. But this must not become a goal in itself. Even life in the station is difficult now, because it is crammed with equipment. We hope that this "construction schedule overrun" will at long last come to its logical conclusion and that "Mir" will get its long-awaited additional instrumentation modules this fall.

[Konovalov] Vladimir Aleksandrovich, commercial terms are now used in our conversations, we are adopting new conditions for the launch of foreign cosmonauts. Naturally, the following question suggests itself: Is it necessary to award them the title of Hero of the Soviet Union? Even if we do consider it necessary to recognize their personal contribution to the strengthening of cooperation with our country, we do have other awards.

[Shatalov] I agree with you. The situation has changed and appropriate conclusions must be drawn.

[Konovalov] It seems to me in general that the Hero's Star and the award of general's rank and degrees of candidate or doctor of sciences to cosmonauts is simply a way of supplementing their low salaries. Could it be simpler to reward them properly for their hard and risky labor?

[Shatalov] The press has now started asking: Why should the military fly in space? But why not? More than 50 percent of cosmonauts in the United States are also military. NASA is now headed by cosmonaut Admiral Richard Truly. A general's rank in our country is awarded not for flights but according to the office held. Some cosmonauts are graduates from the General Staff Academy and hold a general's rank in the Army. This is a natural progression for capable people. I see nothing dangerous in it. In the same way, many civilian cosmonauts are elected as higher education establishment rectors or become professional scientists when their flying career ends. The situation is the same in the United States.

Regarding salaries, they are of course not large. A cosmonaut earns R300. There is a 10 percent supplement following his first flight. Three flights result in a 15 percent supplement. A 20 percent supplement can be earned after five flights. All military cosmonauts receive the same additional titular payments, while incentives for civilian cosmonauts are the same as for all enterprise workers.

Test flights involving space technology could produce bonus payments ranging from R2,000 to R15,000.

For comparison purposes: When U.S. astronauts join NASA and retain their military rank, they receive $40,000 a year.

[Konovalov] What do you feel about the USSR Journalists Union's decision to aim to have a Soviet correspondent fly in space, to be followed by a foreign corespondent?

[Shatalov] We are ready to train both a Soviet and a Japanese journalist for flight. All cosmonauts have great

respect for journalists' work, and we will do everything possible to help them in their work.

I personally think that a flight by a Japanese journalist would be more useful. It would be more productive in propagandizing our cosmonautics. It is one thing when you praise or criticize yourself, but it is something quite different when others talk about you.

But I think that when training a Japanese citizen for a flight, we could obtain more benefits than is envisaged at present. It is a shame that our mighty industry has not organized the production of good space souvenirs and modern children's toys. Japan specializes in this sphere and we could set up a joint venture to propagandize cosmonautics. Life proves that this is by no means superfluous. We have not missed the train yet, it is not too late to set up such a venture.

We are on the threshold of the epoch of commercial spaceflight. It is time to start propagandizing it on a proper commercial scale.

Economic Benefits From Materials Developed For Space Program

LD2205014589 Moscow Television Service in Russian 1700 GMT 21 May 89

[From the "Vremya" newscast]

[Text] Here is what we can get from conversion in the field of space research. For the first time, we have on our program a report from the main enterprise for the development of construction materials.

[Correspondent P. Orlov—identified by screen caption] This was the first time that we were able to see for ourselves, and now we can show you, how and from what materials our satellites, spacecraft, space stations, and launch vehicles—which have been flying in space and returning to earth for 30 years now—are made. Our space program was created by hitherto unknown experimental design offices, scientific production associations and scientific research institutes, all the way from ideas to the complete—I emphasize complete—fitting out of industrial production facilities.

Composites that are light, strong, and practically everlasting; bearings that can withstand any temperature; materials that do not fear corrosion and are biologically inert; foam seals that will not let even a molecule through; the "Energiya" and the "Buran" are 80-percent made from such materials. [video shows drawings and photos of spacecraft; a welding or cutting operation; footage of a "Soyuz" launch vehicle take-off; various pipes under a board saying "carbon-carbon composites," "metallic composites," "high-strength steels," "superlight aluminium alloys"; cross-sectioned bearings; man holding up a concoction of metallic brackets; samples of materials on display; footage of "Energiya-Buran" on the launch pad]

So from whom was all this being concealed? From foreign competitors? But they have either already arrived at this or are now ready to buy it from us for any amount of money. So was it from our own people? Were these needleless vaccine injectors concealed from parents, for example? Were these pipes that need no repairs concealed from builders? Or, for example, was this sewing machine, which stitches the interior lining of the "Soyuz" spacecraft, concealed from housewives? [video shows equipment in open cases; pipes; hand- held miniature sewing machine stitching cloth]

[S.P. Polovnikov, director general of the Komposit scientific production association—identified by screen caption] Even experienced specialists in various fields are astonished when they come to our enterprise, they say: Have we really got this in our country? And we really do have it in our country. Today restructuring has made it possible to sell these achievements to the country's national economy. We must not miss this opportunity.

[Orlov] What do we need for this?

[Polovnikov] I think we will begin, or rather have already begun, by converting one of our works, which will be able to produce tens of thousands of tonnes of goods from such materials. Today we need customers to respond as quickly as possible. Then the country's national economy, the agro-industrial complex, the chemists, the engineers, the power engineers will get everything shown here. We have assembled all this and realized it. That is why we are not lagging behind the Americans, and even more so other countries, in space. Well, this is our national wealth, which should be made to benefit our people as quickly as possible.

[Orlov] Now the Komposit scientific production association is open, not only to journalists, but also to representatives of every other sector of the national economy. Here they are already to transfer technology and train specialists, and the most important thing is that they have already started this work.

Well, if it were up to me, I would invite here, first of all, those people's deputies who are proposing to cut back the appropriations for space programs. Let them look and work it out for themselves. Believe me, there is enough materials here to give new life to many fields of our economy and to restore a sense of national pride. [video shows various exhibits, containers, sailboat; rolling caption: "The economic effect from the application of composites in the national economy could amount to R41.6 billion"]

Dunayev Stresses Benefits From Manned Program

LD2305113589 Moscow TASS in English 1121 GMT 23 May 89

[Text] Moscow May 23 TASS—Soviet Glavkosmos chief Aleksandr Dunayev stressed the great importance of the work done aboard the orbital complex Mir for fundamental science and the economy of the Soviet Union. He

was speaking at a news conference in the Soviet Foreign Ministry press centre today.

Dunayev said tht the cost of developing and operating the Mir station, from its launching in February 1986 until the return to earth on April 27 of its latest crew amounted to 1,471 million roubles.

The sum covers the cost of launching the main station unit, the Kvant astrophysical module, the Progress ferry spacecrafts (7-8 per year) and the crew delivery vehicles as well as the costs of creating two new modules and the Gamma observatory.

"In the course of the mission, we conducted 824 communication sessions devoted to 64 scientific experiments in the fields of astrophysics, space technology, terrestrial natural deposits prospecting, space biology and medicine", cosmonaut Aleksandr Volkov said. "These included the use of 64 million hectares of arable land in the Ukraine, Moldavia and the Krasnodar territory, the pastures of Kalmykia and Kazakhstan, the dynamics of pollution of the Volga, the Black and Caspian Seas and the Sea of Azov. The information was fed directly to those who had ordered it."

Of the technical experiments, Volkov described as one of the most interesting the measurements of pressure outside the station with the help of a 10-meter rod extending from the locking section. When uncoupling the Progress-40 ferry craft an experiment was successfully carried out with unfolding a large-scale construction with metal links that can "remember" their previous arrangement. The process of unfolding and subsequent vibrations were recorded on film and videotape.

Academician Rashid Syunyayev said that the X-ray telescopes installed in the Quant astrohysical module provided unique pictures of the spectra of the supernova which flared up in the Large Magellanic Cloud and the nova in the Little Fox [Vulpecula] constellation as well as data on the modification of the revolution speed of the neutron pulsars.

When preparing the station for its automatic flight, the crew performed the necessary repair and restoration work on its on-board systems. A new crew is due on board the Mir station in August of this year.

Speaking about the reasons for discontinuing the piloted mission, Dunayev cited delays in building two new modules, one technological and the other with additional equipment whose docking was scheduled for May. "Besides, for economic considerations the interval between the launchings of the two modules should not exceed 3 to 4 months. This was why the original schedule was waived. The technological module will be launched in December, preceded by the other one in October," he said.

Economic Benefits of Space Program Stressed at Cosmonaut Press Conference

LD2405053989 Moscow Domestic Service in Russian 1500 GMT 23 May 89

[Excerpt] A press conference was held today at the USSR Foreign Ministry press center in Moscow. It was devoted to the results of the flight by cosmonauts Volkov, Polyakov, and Krikalev aboard the "Mir" orbital complex. Our correspondent,. Yuriy Korotkov, has prepared a report on the press conference.

[Korotkov] Cosmonauts Volkov, Krikalev, and Polyakov, who ended their flight aboard the "Mir" station on 27 April, and leaders of the USSR Glavkosmos [Main Administration for the Development and Use of Space Technology for the National Economy and Scientific Research], The Gagarin Cosmonaut Training Center, the Institute for Space Research, and medical establishments exploring medical and biological problems, attended the press conference. The feedback from, and cost of space operations was the main aspect emphasized by all the speakers. True, many people have been asking more and more often lately whether such flights are justified and what, in the final analysis, they provide in practical terms for science and for the national economy, as well as for all of us. Aleksandr Ivanovich Dunayev, head of the USSR Glavkosmos, gave the following figures. Over the past 4 years, our country's expenses on manned programs amounted to R1.471 million. And what is the feedback? Taking the commercial profits only, we received about $600,000 over the period of the "Mir" station's operations. What has the station brought to our country? What are the results? Here is what Leonid Alekseyevich Gorshkov, head of a department of the Energiya scientific and production association, said.

[Begin Gorshkov recording] Here is what I would say about the areas in which we believe we are receiving important results. First, they include results that bring direct revenue in to our national economy. These are, mainly, the production of materials, biopreparations, and the exploration of earth resources. The second area, of course, is commercial activity. This is very lucrative work, on the whole. This is the marketing of the results of advanced technology and not the marketing of resources, and is a serious achievement, of course. Third, there is scientific research. As a rule, this research does not yield results that can be expressed in monetary value, and perhaps it would be wrong to expect that. The last thing is the introduction of our technology into industry and the national economy. I must say that we never thought about this before. Our achievements and development are common property, as the saying goes. They have been used, but we have been unaware of many things. To clear up this area special work should be done now. However, the press has written, perhaps, about individual instances: glass-reinforced plastic, carbon-filled plastic, various glues and coatings, and a whole range of technical designs have already been used in the national economy. [end recording] [passage omitted]

Energiya-Buran System To Save Billions of Rubles

LD2705164189 Moscow TASS in English 1539 GMT 27 May 89

[Text] Moscow May 27 TASS—The expected economic effect from using in the Soviet economy the "Energiya-Buran" reusable space system and scientific and technical achievements, gained during its creation, is estimated at 4-5 billion rubles per year. This will make it possible gradually to compensate for the cost of the system, which has added up to 14 billion roubles over 13 years, Vitaliy Doguzhiyev, Soviet minister of general machine building, said. He made this comment in the lastest issue of the "Government Herald" regarding the discussion by the Presidium of the USSR Council of Ministers of the issue of using in the national economy scientific and technological achievements produced by this space rocket system.

With the help of "Energiya-Buran", it is planned to conduct the orbit servicing of satellites of electronic and radar observation. This will enable to increase the service life of unique equipment from 2-3 to 5-7 years and longer, or to cut production costs.

Vitaliy Doguzhiyev reported that 600 original scientific and technical achievements were made available to ministries and departments: new technologies and materials, machine tools and devices, programs and methods, experimental equipment, measuring equipment and automatic control systems. This huge multi-sectoral scientific and technical potential is being geared to meet the needs of the economy. Many developments have been already tested and mastered in various branches of the industry, the minister stressed.

Testing of the reusable "Energiya-Buran" space system, Vitaliy Doguzhiyev said in conclusion, has not been finished yet, but it already brings the economic effect.

Semenov Defends Achievements, Profitability of Space Program

18660173 Moscow PRAVDA in Russian 13 May 89 Second Edition p 3

[Article by Yu. Semenov, chief designer for manned space vehicles and stations, corresponding member of the USSR Academy of Sciences: "Three Years on Shift"]

[Text] **The latest stage of work on the "Mir-Kvant" orbital complex is complete. Cosmonauts A. Volkov and S. Krikalev have returned to earth after spending 151 days working on the station. The long-duration flight of physician researcher V. Polyakov, who was on the station 4 months before V. Titov and M. Manarov landed in order to help make preparations for this crew to return to earth after a year-long flight, lasted 241 days. This is the first time that such a long period of work in space has taken place and it was necessary to conduct professional medical observations and prepare the long-duration cosmonauts for the landing. V. Titov and M. Manarov now feel normal. But in order to make decisions about further increasing flight duration, prolonged studies are required.**

The research program aboard the "Mir" complex is now in automatic regime. This makes it possible to carry out preventive maintenance on the ground facilities—the flight control center, the communications posts, and so forth. And during the latter half of the year it is planned to launch another crew to "Mir." It will also be necessary to dock two heavy modules with it carrying complex maintenance and scientific apparatus. Tests will also be conducted on a new modification of the "Progress" cargo craft and work will be done on facilities for autonomous activity by a cosmonaut in open space and on other experimental equipment.

But first of all it will be necessary to analyze what has been done aboard "Mir" during the 3 years of its labor shift in space.

I recall that four main expeditions have worked aboard the station along with five visiting expeditions, of which four were international. In all, 19 cosmonauts worked aboard the station, including representatives of Syria, Bulgaria, Afghanistan, and France. A total of 25 cargo vehicles were sent to "Mir," of which 7 were manned. Of the 1,162 days of its flight, 880 were done with a crew aboard.

The station's flight showed that manned orbital complexes are today a peaceful testing range for testing space equipment and an outpost of priority directions in fundamental science. This is testified to eloquently by the fact that during the 3 years about 5,000 sessions took place for various kinds of research that employed more than 60 designations of research equipment and equipment having a total weight of 9 tonnes. Several hundred kilograms of material were delivered back to earth along with the results of studies in the fields of astrophysics and geophysics, space technology and biotechnology, and biology and medicine, and space technology was further developed.

A fuel-free [bezraskhodnyy] attitude control system using power gyrostabilizers, a unified control system that makes it possible for vehicles to approach the station while remaining constantly oriented on it, and a new life-support system that eliminates the need for regular deliveries of air oxygen regenerators to the station, were introduced for the first time on the station and put through comprehensive tests. As the result of freeing up facilities that otherwise would have had to be used on the cargo craft, it was possible to use them for additional service and scientific equipment, which over the 3 years amounted to more than 24 tonnes.

The complex of service and scientific equipment made it possible to conduct a number of assembly operations in orbit using structures of large mass and dimensions (solar batteries, antennas, beams). The repairs to the X-ray telescope carried out during extravehicular activity in open space, during which new instruments and methods for restoring the work capacity of the

equipment were tested, extended experience in and opportunities possible during extravehicular activity.

For almost 2 years the "Kvant" vehicle was docked with the "Mir" station and the Rentgen international orbital observatory is functioning successfully and providing unique scientific results. The detection of hard X-ray radiation from the supernova made the "Mir" station the main source of information for scientists throughout the world about the processes that take place during the death of a star. The formation of iron was recorded in the envelope of the supernova as the result of the radioactive decay of cobalt. During the course of observations of other sources hard X-ray radiation was detected with a temperature of a billion degrees coming from the an X-ray nova in the constellation Vulpecula, and X-ray images were obtained of the central field of our galaxy and the Greater Magellanic Cloud.

In order to solve specific national economic tasks, photo surveying was done on orders from the Priroda State Center. The interests of 150 organizations were taken into account when this was done. Territory covering an area of 20 million square kilometers was recorded on film.

Material from space photography made it possible, in particular, to look in a new way at the problem of the Aral. Fundamentally new results were obtained in revealing the structures typical of oil and gas deposits. Just with the help of work on materials from space photography it turned out to be possible to establish, for example, that Tajikistan has 1.5 times more pastureland than was thought. It was shown that in that same republic 500,000 hectares of pastureland need improvement.

Unfortunately, because of the shortcomings in facilities and technical possibilities, only about 40 percent of national economic requirements for information obtained from space photography from manned and automatic space equipment were satisfied.

That is why provision is being made for the module that it is planned to launch to "Mir" in late September 1989 for the installation of a new videospectrum complex controlled by radio from the flight control center. The ultimate goal of this direction in space research is the development of a service to provide constant ecological monitoring and an opportunity to prevent the damage that experts assess at R1.1 billion annually. By the beginning of 1991 it is planned to launch to the "Mir" station a module equipped with apparatus that operates in various parts of the electromagnetic spectrum.

It is understood that these facilities can also be used for the needs of monitoring disarmament processes on earth and for observing agreements on the nondeployment of nuclear weapons in space, and hence to promote the cause of strengthening world stability and trust.

Technological experiments aboard the "Mir" orbital complex have been aimed at doing work on base processes in the crystallization of semiconductor materials for the purpose of preparing for the production in space of test batches of gallium arsenide, zinc oxide, and cadmium sulfide for the fabrication of instruments based on them. The effectiveness of methods for obtaining monocrystals of zinc oxide for ultraviolet photography has been confirmed. Principles have been developed for the production of silicon films to develop very large integrated circuits. They guarantee up to 90 percent yield of good-quality product while technologies on earth give much less. Already today it is possible to find in the test laboratories of the Ministry of the Electronics Industry samples of apparatus, in particular apparatus employing laser quantoscopes (television with an image area of 10 square meters), developed with the use of monocrystals of cadmium sulfide obtained in space and having technical characteristics not found in analogues made on earth. Annual demand from the Ministry of the Electronics Industry, the Ministry of the Electrical Equipment Industry, and the Ministry of Defense Industry for materials made in space is today assessed in tonnes, and this promises a savings of at least R400 million annually.

But space technology still does not have these kinds of production facilities at its disposal. On the technological module that is to be sent to the "Mir" station late this year it is planned to organize test industrial production in volumes of up to 100 kg of material annually. In order to satisfy the needs of our industry new-generation complexes are needed that should replace the "Mir" with masses of hundreds of tonnes and energy supplies of up to 500 kilowatts. Test work with the "Mir" station and the "Energiya-Buran" complex that has been developed are opening up opportunities to realize this task.

Biotechnological experiments have been conducted on the highly productive Ruchey and Svetlana installations and on the Aynur and Biokrist biocrystallization installations. The results are encouraging: For example, productivity in processes involving the electrophoretic separation of protein preparations with a high degree of purity and a thousand times better than on earth. Test batches of genetically engineered interferon have no impurities or biologically inactive forms; on earth this is problematical. Monocrystals of proteins delivered from "Mir" to earth are being used to determine their structure with the aim of subsequently synthesizing new drugs. Today the task is to meet the demands of the Ministry of Health for valuable drugs and diagnostic preparations. Highly active species of microorganisms obtained in space have possessed the ability to produce 35 percent more agricultural antibiotics than the initial strain and have found application in selection work being conducted in the "Biotekhnologiya" All-Union Scientific Research Institute.

The positive results from experiments conducted are providing motivation for foreign firms to sign contracts to obtain protein preparations aboard the "Mir" station.

Fundamental biological processes studied during the course of the expeditions may also be of practical interest (including in medicine). In particular, data obtained on model projects about the law-governed process of polymerization of biological materials under weightless conditions may be useful for an understanding of the features of life activity at the cellular level. Samples of "molecular screens" have been obtained that possess high resolution in biological analysis of substances.

Results from medical studies make it possible to predict the possibility of conducting even longer-duration spaceflights, including the flight to Mars, on the basis of life-support methods and facilities first developed in the USSR and that have no analogue anywhere in the world; these life-support facilities insure the life activity of crews and maintain their health and work capacity. Patterns have been found in the adaptation of the body to weightless conditions, and these are important not only for space medicine but also in order to understand and prevent disorders under earth conditions resulting from a sedentary way of life and prolonged enforced bed rest.

Material from these studies is also making a contribution to methodology for medical monitoring and managing the condition of the individual in experimental situations (as, for example, prolonged cooling of the body), and in developing methods and means to optimize operator ability, which should be used to increase efficiency and safety in man-machine systems.

This is by no means a complete list of what has been done in work on the station over the past 3 years and it indicates that a serious fundamental basis has been created in the USSR for further planned development of manned spaceflight. In the formulation of international programs we are trying to give priority to research that is most urgent for the development of science here in our country. The agreements provide for the joint use of results, and commercial agreements have been signed with firms in Austria, the FRG, Japan, and the United States.

Today the question of the economic return from spaceflights is becoming increasingly important.

Until recently many domestic economic questions were being resolved without deduction of payment, and cost-accounting relations alone at enterprises have placed the question of accounting transactions on the agenda.

It should be noted that information about the earth obtained from satellites has for a number of years been sold abroad on behalf of the state while within the country it remains a gratis gift to other sectors from space research. The various departments that operate communications satellites in their own interests had no direct financial stake in their development. And what of the numerous human lives saved by the COSPAS-SARSAT system? Are these not examples of the free and effective way that space research serves society?

The development and operation of equipment in space acts as a powerful incentive in the accelerated development of various branches of science and technical progress in the country in general. The history of space research has already provided many examples of the development of apparatus and equipment that is being actively used in the national economy. It is worth remembering that the latest technology for the production of expanded plastics [penoplast], fiberglass materials, special adhesives, and thermal insulation materials have appeared thanks to rocket technology and space research. In the field of metals science, under the influence of orders from the space industry an entire sector has been created—the metallurgy of heat-resistant materials—which is now working for the needs of the country and for export.

In 90 cases of out a hundred the equipment developed for space rocket technology is being used in the national economic interests. For example, just the introduction of filters based on glass materials is providing a saving of R15 million annually in ferrous metallurgy.

The Anaterm anaerobic hermetic sealer developed for and with funding from space rocket technology are being used extensively in automobile construction, shipbuilding, machinebuilding, the manufacture of aircraft, and instrument building, and also in agriculture. The total saving from their use is R17.5 million annually.

Materials and technical processes in welding and soldering developed for uncooled fittings in space engines have been passed on to the Ministry of the Electrical Equipment Industry's Armaelektrosvet Plant for solar light sodium-discharge lamps, which have twice the efficiency of normal lamps. The savings amount to millions of rubles and lighting with the new lamps in Moscow alone has saved enough electric power to provide lighting for a city such as Leningrad.

Materials, heat transfer agents and technology for making high-temperature space heating tubes are being used in heat growing tubes to grow semiconductor crystals. When this is done a reduction is achieved in defects in the crystal structure by a factor of 1,000. The yield of suitable crystals is increased one-third. Some 20 sets of heat growing tubes provide a savings of more than R1 million annually.

Materials and technology for heat-insulation coatings, leads, cables, and magnetic cores with working temperatures of 300 to 900 degrees Celsius have been introduced at 500 enterprises belonging to 11 ministries in order to improve the reliability and service life of electric hoisting and braking mechanisms, electromagnetic rollers in rolling mills, electromagnetic pumps for molten zinc, and induction heaters for vulcanizing presses, and also various kinds of organosilicate coatings to provide protection against corrosion and conflagration in an oxygen environment. All of this is providing a saving of about R50 million.

Extensive use is being made of a modification of "Ripor" expanded plastic, which was developed quite recently as a cold-resistant thermal insulation for tank systems in space rocket complexes. Installations for applying it are being used by the housing construction sector to seal joints. The operation is fast and esthetically pleasing. The savings derived from sealing the joints in a typical 12-story apartment building amounts to R4,600.

Facilities for remote diagnosis of the cardiovascular system and for on-the-spot medical assistance developed in order to provide medical support for space flights are today also being duplicated by organizations engaged in space technology. Instruments such as the Argument and Reograf, designed for space flights, have also been put into production for studies of the cardiovascular system under clinical conditions. Use of the program-controlled Fiziotest instrument that automatically processes data in function tests under stress, and also the Tonus instrument for various therapeutic procedures with a measured dose of electrical stimulation to muscles, also look promising for diagnostic purposes. The task has been set of sharply increasing the production of such apparatus.

Many more examples of the use of space developments in our national economy could be cited. Take just the latest, extensively discussed work to develop the "Energiya-Buran" complex. The total number of developments created for this and recommended for introduction in the various sectors of the national economy is about 600. They include control systems, electronic devices, radiotechnical apparatus, and electrical instruments; software packages for production work; structural, heat-insulation and, special materials; technology and technological equipment; test stands, ground cryogenic complexes; aviation transport facilities, automatic landing equipment for aircraft, special ground transport facilities, and loading and unloading devices.

Drawing back the veil of secrecy will significantly accelerate the introduction of advanced achievements in other sectors.

Manned space research is a mirror of the leading positions of the state in science and technology. Participation in flights on Soviet manned orbital complexes is regarded abroad as an important step along the road of society's political and scientific progress. France, the FRG, Japan, China, and other countries are striving to take active positions in the field of manned space research. Naturally, maintaining leading positions requires serious efforts from the USSR also. And here it is apropos to cite figures on the allocations being made by the United States, the European Space Agency, and Japan for this purpose.

NASA funding in 1988 was $9.0 billion. The budget for the European Space Agency (ESA) was $1.8 billion in 1988. In Japan during the 1988 fiscal year budget allocations for the space program totaled about $1.1 billion.

And what about us?

In 1988 spending for space research was R1.3 billion (less than one-third of 1 percent of the country's state budget). And a saving of about R2 billion was achieved.

Under the conditions of democratization in our country, the national space programs and their economic effect and political significance have been thrown open for broad debate. Notwithstanding, there is bewilderment resulting from attempts to use these conditions for calls to cut back the budget for Soviet space research. Doubt is being cast on the economic advisability of spaceflights, the effectiveness of man's presence in space, and the urgency of further developing work on orbital stations. These issues cannot be approached without an understanding of their enormously crucial nature.

It should be borne in mind that spending for space research is not so great that halting it would make any noticeable contribution to the state budget, while using funds freed up in other sectors of the national economy would produce a great effect. Not everyone knows that in 1988 spending for space research was, for example, 10 times less than the spending by the Ministry of Land Reclamation and Water Resources.

I am convinced that making savings on space research, which embodies the country's lead technology, is impossible. It could cost the state and society and our descendants dearly, while space research runs the risk of losing its impetus and the significance of one of the most advanced and well-organized sectors in the country would be lost.

The USSR has always been an advocate of purely peaceful space research and has repeatedly offered initiatives concerning the creation of a world space research organization. In our time one real alternative to an arms race in space is the promising proposal from Soviet scientists for joint work on a plan for and conducting an international manned expedition to Mars.

The further development of manned orbital complexes is on the agenda; before our very eyes they will become multiple discipline space factories to satisfy the needs of many sectors of the national economy and to produce new materials, medical biological drugs, conduct constant ecology monitoring, and other needs. Ultimately the results achieved will be passed on to everyone and the fruits of space research will be used by everyone.

No 'Buran' Flights in 1989; Shuttle To Be Shown at Paris Air Show

LD1605110389 Moscow TASS in English 1049 GMT 16 May 89

[Text] Moscow May 16 TASS—There are no plans to launch the USSR's reusable spacecraft Buran this year, a senior Soviet space official told newsmen here today.

The Buran carried out a maiden flight in an unmanned mode on November 15 last year.

"The absence (?of flights) this year is in no way connected with technical faults," stressed Aleksandr Dunayev who heads the country's space administration Glavkosmos.

"The Buran has been completely restored and is ready for more flights," he said, adding that the next mission will be conducted when there is a payload that could, at least partially, make up for expenses involved.

Dunayev said that the Soviet space shuttle will actually fly this year even though this will be a piggy-back ride on the new Soviet transport plane An-225 which is to bring it to the Le Bourget air show.

'An-225' Brings 'Buran' Shuttle to Kiev

LD2005195989 Moscow TASS International Service in Russian 1333 GMT 20 May 89

[Text] Kiev, 20 May (TASS) TASS correspondent Valentin Vernodubenko reports:

The "Buran" space shuttle craft arrived here Friday [19 May] evening: It was brought to the airfield of the "Oleg Antonov" experimental design bureau by a "Mriya" "An-225" Soviet transport aircraft, the largest in the world.

The "Buran" was fixed on special external suspension brackets whereby the total weight of the entire transport system on take-off was approximately 560 tonnes, Aleksandr Galunenko, the commander of the enormous aircraft told the TASS correspondent. No other aircraft in the world is yet capable of lifting such a gigantic weight, but for ours it is not the limit. "Mriya" can take off with a total take-off weight of 600 tonnes.

On 10 May, when the "An-225" set off for Baykonur to pick up its unique load, its crew and designers intended that they would return to Kiev nearer 25 May. However, it was possible to speed up the work considerably. After the first test flights had been carried out in the area of the cosmodrome it became clear that there would be no unpleasant surprises on the flight from Baykonur to Kiev, and the number of test flights was reduced from nine to five: On the sixth occasion the crew set course for the Ukrainian capital.

Today the designers inspected all systems of the air freighter and decided that they were fully in order. The aircraft will now make a flight to Moscow with the "Buran": The "tandem" will then return to Kiev. It will leave there at the begining of June for the 38th International Air Show at Le Bourget, near Paris. The Soviet exhibition there promises to be one of the most representative. Along with the "Mriya" the USSR will be showing modern military equipment, including the "MiG-29" fighter, and the "Su-27" interceptor. Passenger airliners will also be shown: the "Il-96" airbus and also the medium-range "Tu-204."

'Buran' Grounded for Economic, Not Technical Reasons

PM2305123189 Moscow KOMSOMOLSKAYA PRAVDA in Russian 21 May 89 p 1

[Reply by A. Dunayev, chief of the USSR Main Administration for the Creation and Utilization of Space Technology, to reader's letter: "'Buran' Laid Up?"—first paragraph is reader's letter]

[Text] What has happened to our "Buran" since its flight? It is said that the next launch has been postponed owing to technical faults. [signed] A. Vinogradov, Kiev

A. Dunayev, chief of the USSR Main Administration for the Creation and Utilization of Space Technology, replies:

"This information has indeed appeared in certain U.S. publications. But there are no faults. We have simply started counting our costs and relating them to economic and technical expediency. [no closing quotation marks as published]

It is not planned to launch "Buran" this year.

As a TASS correspondent reported yesterday, the An-225 "Mriya"—the world's largest transport aircraft—has delivered the "Buran" to the O.K. Antonov Experimental Design Bureau in Kiev.

The "Mriya" and the "Buran" will soon be setting off for the Le Bourget air show.

Deputy Defense Minister Denies 'Spaceplane' Project

PM1805091189 Moscow SOVETSKAYA ROSSIYA in Russian 17 May 89 Second Edition p 6

[Interview with Army General V.M. Shabanov, USSR deputy defense minister, by N. Dombkovskiy under the rubric "Reliably Known": "The 'Canard's' Space Orbits"—date and place unspecified; first six paragraphs are editorial introduction]

[Text] The popular magazine SCIENTIFIC AMERICAN recently discussed the Soviet space program and gave readers the sensational news that the USSR has allegedly developed [sozdan] an unusual craft—a small spaceplane. Here is the word-for-word text from the magazine:

"Another addition to the range of Soviet space systems is a small reusable spaceplane. Soviet officials still have not admitted the fact that the USSR has such a machine. However, its existence was discovered a few years ago, when an Australian Air Force aircraft flying over the Indian Ocean photographed a scaled-down spaceplane model...

"Western specialists believe that the SL-16 rocket could be used to place the spaceplane in low-earth orbit; the

plane can carry a crew of two or three and quite a small payload; the plane is probably able to land on a standard runway. It can also be used to transport people from one spacecraft to another, to inspect satellites, and as a quick-reaction rescue craft...

"The scaled-down spaceplane model was photographed by an Australian Air Force aircraft overflying a Soviet ship. The deckhands retrieved the model from the water after it had landed following a test flight. The actual spaceplane would probably be 2-3 times larger than this model."

It has to be admitted that we have never heard of such a craft developed [sozdannyy] in our country. At the same time, a definite conclusion suggests itself: The magazine is gradually leading readers to believe that a fundamentally new kind of space weapon—a craft able to put orbital spacecraft out of action—already exists in the USSR.

We asked Army General V.M. Shabanov, USSR deputy defense minister, to comment on this report.

[Shabanov] This report in the popular U.S. magazine should be put down as a "canard." Our country has no such craft. Incidentally, there is nothing similar in the entire world. Back in the early sixties the U.S. Air Force looked into the possibility of building a spaceplane. This was done under the "Dynosoar" project. But work stopped in 1965 for two reasons: There was no definite possibility of using the craft in a military program and the project cost was astronomical.

[Dombkovskiy] Don't you think that the magazine report is aimed at prompting U.S. legislators into returning to that program?

[Shabanov] I have no information on that score, but I think it should not be ruled out. All the more so as Europe is already planning to develop [razrabotka] a similar craft.

[Dombkovskiy] Just what is visible in the picture?

[Shabanov] This is perfectly clear. During the development of the "Buran" shuttle four mockups [model-analog] were launched. They were launched under the "Cosmos" classification system, numbers 1374, 1445, 1517, and 1614. Heat-shielding elements, guidance systems, and so forth were worked out on the models. It was one of these models that the Australians photographed. [Shabanov ends]

...We would add that journalistic ethics demand that we discuss in the subjunctive things that are not reliably known. In this case our colleagues from SCIENTIFIC AMERICAN deviated from this rule.

Council on 'Phobos' Failure Ends Meeting

LD1805224589 Moscow Domestic Service in Russian 1500 GMT 18 May 89

[Text] [Announcer] Today the meeting of the scientific council on the 'Phobos' project finished in Moscow. You know that this project, by using two space vehicles, was set up to study the interplanetary environment of Mars and Phobos, its satellite. However, both crafts were lost, one in the first stage of the flight and the other in the immediate proximity of Phobos. Our correspondent, Leonid Lazarevich has just returned from this council. I have a question for you. What has this mission nevertheless given to science? What was reported at the council?

[Lazarevich] However bitter it is that two stations have been lost, they had time to fulfil part of the scientific research, quite a large part of it. During one of the sun's flares, the emission of plasma and the distance of it from the radius of the sun was registered. Phobos was photographed. It was established , for example, that the daytime temperature on Phobos is minus 27 Celsius- - this is during the day. In my opinion this is interesting. A hundred sessions were held and 100 bursts of hard space radiation [zhestkoye kosmicheskoye izlucheniye] were registered.

There was a lot of interesting information and there will be reports. There were reports at the council. Material will be published. Nevertheless, one cannot ignore the fact that both stations were lost. Let me say immediately that there is as yet no final conclusion as to why this happened, but there are some theories. There are many different theories and they are very complicated. The developers of the scientific apparatus and the developers of the stations do not agree. There are mutual accusations, they were rather sharp and emotional, but now, in my opinion, a very important event has occurred. An international council has been formed to analyze everything that happened with "Phobos 2." What seems to be to be particularly remarkable is that this council, you know, is not only there to carry out an analysis of what has already happened. All future stations will be created with this council's participation.

Ahead, we have very many projects, which will be created in a program of international cooperation. The exploration of Mars is set to be carried out before the end of the century. The next project will be the "Mars-94" project. You know what worries me? This project is planned. It should take place but the question of how it is to be financed has yet to be decided. This means that in the final stage, when the time of this astronomical window approaches, a rush hour will start again. This is what happened with "Phobos 2," and you know what that led to.

[Announcer] All in all, that should not be repeated.

Reports on Space Costs, Benefits

Space Spending Figures Cited

PM0506135589 Moscow KOMSOMOLSKAYA PRAVDA in Russian 4 Jun 89 p 1

[Answer to reader's question from unattributed "Dialogue" feature: "Money Thrown into the Air?"—first paragraph is reader's letter]

[Text] "The Congress of USSR People's Deputies has finally revealed the figure that we spend on defense. But the figures for the spending on space programs have still not been made known. [signed] Yu. Vdovin."

We spent 6 months seeking a reply to this question. "Our spending is fully comparable with that of the United States," was the vague reply from many authorities who then... hung up on us.

It was only yesterday that your "Dialogue" correspondent together with a group of USSR people's deputies found out that it costs from R5 million to R12 million, depending on many factors, to launch the "Proton," "Soyuz," or "Zenit" launchers. The first launch of the "Energiya"-"Buran" space system cost R400 million, but R170 million were "recouped" along with the reusable spacecraft.

At the same time, spending on the use of space equipment working solely in the interests of science and the national economy came to R1.1 billion for 1988, but the economic benefit from its use exceeded R2 billion. After the "Energiya"-"Buran" system flight the USSR Ministry of General Machine Building produced more than 600 technical innovations for use in the country's national economy.

Yeliseyev on Value of Space Research

LD0306055689 Moscow in English to North America 2200 GMT 2 Jun 89

[Report on interview with former cosmonaut Aleksey Yeliseyev by unidentified Moscow radio reporter in the foyer of the Kremlin Palace of Congresses; date not specified; recorded]

[Text] Apart from slashing defense spending, Mikhail Gorbachev announced in his address that some space research programs would also be revised and curtailed. Our reporter talked with a noted Soviet space expert and a former cosmonaut himself, Aleksey Yeliseyev. He had this to say.

[Begin Yeliseyev recording in Russian with superimposed English translation] Space research nowadays on one hand brings us new knowledge of the world in which we are living—our space research answers questions whether or not man can regard outer space as a prospective place for habitation; on the other hand, scientific achievements and technologies derived from space research present practical value. For example, today we take it for granted that Moscow television programs can be picked up in practically any point of the Soviet Union. This would be impossible without the use of space communication and communication satellites in particular. Such a nationwide television hookup would have been impossible through any other means, like laying cables, for example. There are other examples, of course, like weather satellites, navigation satellites, search and rescue satellites; and there are satellites which are designed to monitor environment and natural resources. All these give us a return on the money invested. [end recording]

[Announcer] Aleksey Yeliseyev, however, indicated that the results of space research were not properly utilized in this country, and he made this comment.

[Begin recording] [Yeliseyev in Russian with superimposed English translation] First of all, each space flight should be substantiated in advance, and secondly all the technological achievements derived from space research should be made available to the industries. This is not always the case here. For many years we have had (?partitions) between ordinary enterprises and those working for top-level space effort, and therefore there was a paradox when in one field we were at the top of technological achievement while the field being tackled by that other ordinary factory was lagging far behind.

[Unidentified reporter] Should the Soviet Union curtail its space research effort still further? Demands to this effect are being heard almost daily in the Kremlin Palace of Congresses these days.

[Yeliseyev] I take such statements with a grain of salt. We should never ever think of slackening our scientific research, and specifically in space. We must bear in mind that in science today we lag far behind the advanced countries. You probably have taken note how many Nobel Prize winners are there today in the scientific world, and you would probably have trouble trying to remember at least one name from the Soviet Union. So we cannot afford to cut our research effort, but we should certainly spend our money wisely. [end recording]

[Announcer] That was Aleksey Yeliseyev, a former Soviet Cosmonaut and currently director of Moscow's Bauman Institute, talking with our reporter in the foyer of the Kremlin Palace of Congresses.

Sagdeyev, Feoktistov, Golovanov Discuss Space Program

LD0908165889 Moscow TASS in English 1609 GMT 9 Aug 89

[Text] Moscow August 9 TASS—Participants in a round-table talk, which was published in the newspaper MOSCOW NEWS today, emphasised the need to elaborate a sensible and balanced space research program and define a strategic line in space exploration.

Academician Roald Sagdeyev, people's deputy of the USSR, Konstantin Feoktistov, pilot-cosmonaut of the USSR and doctor of sciences (technology), and Yaroslav Golovanov, a writer, shared their reflections on the not-easy problems of modern cosmonautics. They spoke, in part, about a relatively low efficiency of some development projects and the low return from the application of the results of space research in the national economy.

For instance, Feoktistov has estimated that hauling payloads into orbit with the aid of the new space shuttle Buran will be 20 to 40 times costlier than in using Soyuz and Proton expendable rocket boosters. These rockets are dependable and have long been in operation. The delivery of cargo to the orbital station will also cost ten to forty times more than with the aid of Progress tanker-transport vehicles. Although the development of the Buran failed to get a cheap re-usable spaceship to ferry space cargoes, the spending of money on this is continued, Feoktistov said.

Academician Sagdeyev emphasised the need for new approaches to carrying out space research. In this regard, he pointed to the efficiency of boosting international space cooperation on the commercial basis.

Participants in the talk were of one mind that the Soviet space program can be modified in the right direction if it is put to a public discussion and then submitted to the consideration and endorsement of the USSR Supreme Soviet.

Poor Organization Impedes Economic Profit From Space Sector

18660177 Moscow SELSKAYA ZHIZN in Russian 18 May 89 p 3

[Article by V. Kobelev, professor, doctor of technical sciences, and A. Bachmanov, candidate of technical sciences, "Selskaya Zhizn" science reviewer, under the rubric "You Wanted to Know": "Economic Return From Space Orbits"; first paragraph is a question sent in by I. Vasko, from Sokuluk, in Kirghiz SSR]

[Text] **"How do we get back the outlays that are made for the launching of manned and unmanned space vehicles?"**

The public—not to mention the rank-and-file readers—has recently been devoting more and more attention to the subject of expenditures on space and the economic return from such work. During each new manned international flight many are interested in the question: how much will this flight cost our partner, and how much revenue will it bring our country?

The changeover to cost accounting and to a new economic policy has also affected the space program. Although this sector is a long way from self-financing, the transition to cost accounting has already been mapped out. For example, at one of the press conferences during the summer of last year, State Commission chairman K. A. Kerimov reported how much it cost the country to launch one Soyuz-type craft. The cost of a seried-produced rocket is approximately 2-3 million rubles. The Soyuz craft are fabricated in small numbers, and therefore they are considerably more costly: 7-8 million rubles. It is expensive to support a flight and costly to train cosmonauts and to operate the Flight Control Center and the ground-based network of tracking stations, which includes shipboard stations located in different parts of the world ocean.

Depending on the number of joint experiments, the cost of a week-long flight of a foreign cosmonaut varies from 10 million to 20 million dollars.

We've heard claims from many cosmonauts that the results of observations, attained by enormous work, in the form of space photographs and spectrograms of the Earth's surface, remain in the archives of the "Priroda" State Center. Even the data published in the open press show what possibilities systematic and day-to-day use of space monitoring materials (inspections of the Earth's surface) can afford. This also includes the evaluation of ecological situations in different regions (such as the pollution of Lake Baykal by the rivers flowing into it, the condition of the Kara-Bogaz Gol in the Caspian Sea); the routine evaluation of the condition of trails for seasonal cattle drives in order to select those best supplied with grass; estimation of the presence of moisture in the soil and its flow during presowing periods, which makes it possible to carry out sowing at the best times; and many other quite specific terrestrial events.

More than 10 years ago scientists developed means for the effective use of space information collected with the instrumentation existing and operative then in space systems, proposed new methods for the processing of this information, and validated and checked new, experimental, more advanced methods for its collection. Representatives of different sectors—the users of this information—have given and continue to give verbal support to this scientific research work. But there have yet to be any serious steps for the practical implementation of the results of space monitoring in the day-to-day solution of economic problems.

You must remember that the use of most types of space information (for the needs of agriculture, forestry and fishing and for finding means for taking urgent measures to eliminate the ecological consequences of catastrophic events such as the accident at the Chernobyl nuclear power station) requires on-line processing and delivery of this information not only from space to the Earth, but also—here on Earth—to the user. For example, information that meets the needs of agriculture must be received no more than two or three days after it is collected aboard a space vehicle.

It's no accident that, for the needs of the economy, we use information which, for the most part, virtually does not change with time—for example, maps of the geological structure of the Earth's surface and information for geodesy, construction of major projects, etc. In other

words, the solution of the problem of the use of data of the space-based sensing of the Earth's surface is not complex. A pretty good system has been developed for collecting information, but its routine processing and dissemination to the user is absolutely unsatisfactory. It is precisely for this reason that there is a poor return on the outlays that are made for the collection of information.

The reason for this situation is that many space agencies are closed entities. And although they receive the results of space research, no consumers have any cost-accounting relations with them yet. As in all our economy, it will be possible to speak of the profits and profitability of space only when economics itself turns the space agencies and the users of space information back around to face the Earth, and incentives appear for the development of practical applications. And that will be possible only when there is an open discussion of space agency budget items, when the directors of our planning agencies exhibit a sense of responsibility for every ruble spent on space. Then, the feeling of a "bottomless barrel" of state resources will disappear from finance issues. But for the time being, "Glavkosmos" continues to spend money steadily, because the money is being allocated by the state on an equally steady basis. But who will apply the results of this activity is not, unfortunately, defined in norm-setting documents.

Highly cost-efficient unmanned satellites have long been used in solving many vitally important problems. They are extensively used by television, communications, meteorology and geology, and they are employed in the search-and-rescue of accident victims. Many other uses can also be mentioned. The passive space vehicle "Etalon" ("Cosmos-1989") was recently launched for solving problems in geodesy and geodynamics for purposes of earthquake prediction. Mounted on its spherical surface are more than 2,000 optical "cat's eyes" fabricated from fused quartz in the form of a trihedral pyramid. These optical elements reflect the radiation incident on them in a strictly inverse direction. Thus, when the satellite is illuminated with laser radiation, it returns the beams of the ground-based laser stations and enables highly accurate rangefinding measurements and the identification of minute (1-2 centimeters per year) changes in the position of ground points and gravitational field parameters. This is one of the examples of the practical value of automatic satellites.

But many readers complain about the fact that some 2,000 of them—the satellites of the "Cosmos" series—have been launched over a period of 20 years or so. Isn't that a lot? In the first place, that number of satellites is about right in terms of the needs of a large, modern country that has space technologies. The journal of the Federation of American Scientists (FAS) for November 1983, No 9, gives a forecast of the launches of American and Soviet satellites for 1989. The U.S. plans call for 141 unmanned satellites, whereas USSR plans call for 67 (not including spacecraft and supply ships). Second, there are technical limitations on the lifetime of satellites at the currently used orbital altitudes of motion of artificial earth satellites.

We recall that satellites, like any automatically controlled apparatus, have on-board systems with a limited operational life. For example, the on-board storage batteries of the power supply systems become inoperative after 5-7 years, which puts an end to the active life of the satellite. Second, the modern component base is completely replaced over 5-7 years, and the capabilities of satellites launched 5-7 years ago will not conform to the modern requirements of the problems they are put into orbit to solve.

For that reason, in place of the no-longer-functioning satellites it is necessary to launch newer and newer satellites, that is, to restore the orbital structure of the space system. That is why so much attention is being given to the development of a reusable space system, one of whose jobs is to do repair and maintenance work on satellites that have been launched and to remove them from orbit for the purpose of possible modernization. Without question, working out these problems will enable a sharp increase in the economic efficiency of the use of space vehicles.

Many satellites of the "Cosmos" series are launched in order to debug systems for docking, stabilization and attitude control of orbital stations; their solar cells; docking and attitude control engines; and many other systems and instruments. Accordingly, each satellite launch represents a step in the development of experimental cosmonautics.

Thus, it must be expected that the comprehensive development of space, with systematic organization of the planning and use of space information, can provide the national economy of the country a very great savings. But the problem to be dealt with at the present time is the development of this organized system on a national scale.

Rebuttal of Charges of Excessive Spending on Space

18660185 Moscow ARGUMENTY I FAKTY in Russian No 23, 10-16 Jun 89 p 6

[Articles under general heading: "Profit from Space—R2 Billion a Year. Ambitions or Benefit?"]

[Text] "When will this 'peaceful exploration of space' come to an end? It is impossible to remain undisturbed seeing people's money go down the drain! Come down from the heavens to our sinful earth. We've had enough of soaring in the clouds when people here live in poverty—let us not be afraid of this word. There is no sugar, soap, drugs... Shame! Mother Russia has remained as backward as it used to be!

"Sure, we can understand engineer-designers who get their special rations, draw astronomical salaries and

other benefits. People who have to make it on R80, as, among others, do we health care employees, are of no concern to them. Far from it, they look at blue skies, and we go through hell every day. Yes, this is exactly what the condition of our health care facilities is like. So, is it not better to use the money spent for space in a field as needed as health care? After all, the Japanese live without space exploration, and live in grand style! And not just they."

[Signed] V. Smirnov, S. Kuznetsova. City of Shakhty, Central Hospital imeni V.I. Lenin

Commentary by a Specialist

The opinion has frequently been voiced recently in public statements to the effect that it is necessary to reduce outlays for exploring space, and to invest the funds thus freed up in social development and food programs. Opinions of this kind are sometimes uttered by those who seem to be sufficiently knowledgeable. Such views are probably based on two premises; specifically, that space outlays are so big that they may resolve all issues of foodstuffs, soap, detergents, and so forth. The second argument is that, as the authors put it, "people's money goes down the drain"; that is, space exploration is an absolutely unprofitable sector of the national economy. Is this indeed so?

The outlays for economic and scientific space in our country in 1988 came to about R1.3 billion. For comparison, they amount to one-tenth of the outlays of Minvodkhoz [Ministry of Land Reclamation and Water Resources] and one-twentieth of the investment in capital construction in agriculture. One hundred ninety billion rubles has been allocated for the development of health care up to 1995. Incidentally, we may refer to the "astronomical salaries" of employees in the aerospace industry. The average 1988 salary for people employed in this field was R240, whereas in the entire national economy it was R217.

This is why the result will be very dubious even if all space "expenditures" were to be invested in agriculture, health care, construction, etc. What will we forego as a result of such a decision?

Let us ask the citizens of Siberia, the Far North, the Far East, and Central Asia whether they need communications satellites? After all, it is only due to these satellites, which carry TV broadcasts to 93 percent of the population of our country, that the inhabitants of these regions do not feel isolated from the center of the country insofar as information, culture, arts, and knowledge are involved.

According to data of the Ministry of Communications, satellite communications, radio broadcasting, and satellite TV generated economic results worth R540 million last year. Long-range and short-term weather forecasting, which at present are based in their entirety on data of the Meteor satellite system, generate economic results worth R500 to 700 million annually. We may name many other rubrics of profit from space exploration which convincingly prove that by now it has already become profitable.

In 1988 profits due to the use of space technology in the national economy exceeded expenditures for producing and launching space vehicles by a factor of approximately 1.5, and came to about R2 billion. According to calculations by specialists, this ratio is going to increase in the next several years.

I would like to emphasize the attention paid in developed foreign countries to the exploration and utilization of space. Several countries have their own space vehicles; other countries produce scientific equipment for space experiments. Finally, an overwhelming majority of countries use the services of space communication and navigation systems, and use space data in weather forecasting and the exploration of natural resources. Perhaps the authors of the letter would be interested to learn that budgetary allocations for space in 1988 amounted to about $1.1 billion in Japan and $9.0 billion in the United States. People as businesslike as the Japanese or the Americans can hardly be suspected of the desire to squander money.

[Signed] V. Kuznetsov, first deputy chief of the USSR Glavkosmos [Main Committee for Space Exploration]

Editorial Comment

Thus, some specific numbers on space expenditures and specific returns on them have been quoted, however with much caution, and so far only... for "near" space. However, there is also "remote" space—this includes the "lunar" program, and the "Phobos"... What funds are invested in the latter? Can they be cut without a loss to the country, but rather to its benefit?

As has become known from the speech by N.I. Ryzhkov, the funds are distributed as follows: economic and scientific space—R1.7 billion, military space—3.9 billion, the multiple-use space system "Buran"—1.3 billion, for a total of R6.9 billion.

Joint USSR-UK 'Juno' Space Mission Planned

Agreement Signed

LD2906134189 Moscow TASS in English 1332 GMT 29 Jun 89

[Text] Moscow June 29 TASS—By TASS correspondent Oleg Grigoryev:

An agreement on the first-ever joint Soviet-British space mission, named "Juno", was signed here today. In the presence of Lord Young, British secretary of state for trade and industry the agreement was signed by representatives of the USSR Glavkosmos directorate, the Litsensintorg foreign economic amalgamation and the British Anteguera company.

Juno will be the first space project funded also by British private and international companies active in cooperation with the Soviet Union. One of the project's sponsors and organizers is the London-based Moscow Narodny Bank which is providing starting capital for a marketing campaign and for attracting new sponsors. The mission will enable British research organizations and industrial firms to make use of Soviet space equipment and technology for obtaining specific scientific results.

The British astronaut selected for the mission will become a fully-fledged member of the joint crew that will carry out the docking with the Soviet orbital complex consisting of the Mir space station, research modules and a spacecraft. The blast-off is tentatively scheduled for April 12, 1991, marking the thirtieth anniversary of the first Soviet mannned space flight—that of Soviet comonaut Yuriy Gagarin. The joint crew is expected to spend eight days in space.

The main objective of the Juno mission is for the British astronaut to carry out a series of scientific experiments on board the soviet orbital complex. The series will have been prepared by British scientists on instructions from the sponsors.

Dunayev Interviewed on Project

LD2906134589 Moscow Domestic Service in Russian 1200 GMT 29 Jun 89

[Interview with Aleksandr Ivanovich Dunayev, chief of Glavkosmos, by correspondent Leonid Lazarevich; date and place not given]

[Text] [Presenter] An agreement on a joint Soviet-British manned space flight was signed in Moscow today. This project, which has been named "Juno," provides for joint research by cosmonauts of the two countries on the "Mir" orbital station. Listen to a report by our correspondent Leonid Lazarevich:

[Lazarevich] The agreement on the first Soviet-British space flight will be signed in a few minutes' time. This flight will be the 17th international flight in which Soviet cosmonauts have participated. At the table now are representatives of Glavkosmos, the Cosmonauts Training Center, designers and creators of Soviet space technology and representatives from the British side.

The agreement has been signed. [applause]

And now, an interview with Aleksandr Ivanovich Dunayev, the chief of Glavkosmos.

Aleksandr Ivanovich, when will this flight take place?

[Dunayev] We are planning that we should carry out this flight in 1991.

[Lazarevich] What kinds of experiments, even roughly, are planned?

[Dunayev] There has been a lot of discussion about experiments connected with micro-gravitation. In the main, space technology is a field which is fairly well developed in Britain, especially in the pharmacological field. There is great interest among scientists in Britain.

[Lazarevich] Does this mean that some kind of British scientific equipment will be sent up to the "Mir" station?

[Dunayev] That's true, too, and other variants are possible. Familiarization has shown that they found a lot of interesting solutions in our equipment, and it is possible that an experiment will be staged partially using our equipment.

[Lazarevich] Even when talks were just being held on this project we learned that it would be of a commerical nature.

[Dunayev] I can tell you frankly the price has been set at a good level, within the limits which we set at our last talks with the Japanese cosmonauts. For us this is a satisfactorily advantageous project.

[Lazarevich] That means over R10 million? That we can say?

[Dunayev] You're probably right! [chuckles]

UK Seeks Astronaut Candidate

LD2906215589 Moscow Television Service in Russian 1700 GMT 29 Jun 89

[From the "Vremya" newscast]

[Text] [Announcer] Today the headlines Astronaut Needed, Experience Not Essential appeared in national newspapers and in the business and scientific circles of Great Britain. It is in this way that the campaign to find an astronaut for a flight into space on board a Soviet spaceship is beginning. [video shows the "Juno" emblem]

There are simultaneously two symbols in this emblem for the forthcoming flight: The goose in Great Britain personifies the correct, happy road and the whole Soviet-British space project is called Juno. This is the name of the goddess who is patron of fraternal alliances. Glavkosmos [Cosmonauts Training Center] head Dunayev, Litsenzintorg general director Ignatov, and Professor Heinz Wolff, head of the scientific program—he is the representative from the British company Antequera Limited, specially created for the project—signed the document concluding the alliance.

The representatives from Great Britain call this project historical, though it has been signed by a private company, and the government is not putting any money into it. The 16 million pounds sterling necessary for the selection and training of the astronauts, and for paying for the services of the Soviet Union, will be collected by firms after the campaign, which should arouse the interest of the people of Britain, business circles, and the press. The aim is to acquire financing.

It seems to me that this is an example of that very enterprise and independence about which so much is being said now at the session of people's deputies. Not a penny is taken from the state budget and as a result all expenditure is recouped and all the firms taking part in the project will make a profit. The Japanese television company is thinking and acting in the same way, investing money in the flight by its journalist: The profit will be greater than the expenditure. A Soviet minister who volunteered to finance a flight by a Soviet journalist wanted to proceed in the same way. He wanted to invest and to get back a great deal more, but judging by the barrage of accusations that rained down upon him and the journalists who supported him, it is still difficult for our people to grasp the laws of large-scale marketing, business, and financing. They should understand by now. This very path can make the economy more healthier, not at the expense of the budget but at the expense of enterprise. [video shows the signing ceremony, pictures of the Buran, and then UK minister Young being interviewed]

Western journalists asked Lord Young, minister of trade and industry of Great Britain, whether this was a joke, flirting with the Soviets. In space and in business there are no jokes, he replied.

[Begin recording] [Young in English with superimposed Russian translation] I believe that a marriage of the private and state sectors of Britain and the Soviet Union has taken place here. I think that this is a very good symbol.

[Unidentified correspondent] Does this mean that Europe has accepted the Soviet Union into its family?

[Young] Yes, we are cooperating more and more closely. Here there are now many British firms. I have been in your country on a long visit. I was in the Ukraine, in Leningrad, and now I am in Moscow. It is clear that we are drawing closer together. I think that every country should do what it is successful doing.

[Correspondent] Will this be a one-time space project, with no follow-up?

[Young] I don't think so. Private capital and not the government has given birth to this project. This is a good beginning, and I think that it will have a successful continuation, because in my opinion, restructuring is a delegating of responsibility to a lower level. [video shows news conference with Ignatov, Dunayev, Wolff, and others] [end recording]

[Announcer] The news conference today was unusual. Two hundred British journalists asked questions by satellite to Moscow. Of course there was not enough time, as there isn't for us either, to talk in this reportage about everything. We will return to this subject at a later date, but for the time being a competition has been announced: Any citizen of Britain can fly in space on a Soviet space ship. Happy launchings to this project.

International System Urged For Space-Based Ocean Monitoring, ABM Defense

PM2507102389 Moscow PRAVDA in Russian 20 Jul 89 Second Edition p 5

[Article by Professor V. Etkin: "From Secrecy to Trust"]

[Text] Moscow—After the thermonuclear problem space research is the second sphere of the most advanced science, where fundamental knowledge, technical progress, and defense are linked, and where considerable experience of international cooperation has been amassed.

It is time to use space cooperation to resolve issues which are important for all mankind but currently arouse mutual suspicion in the United States and the USSR.

For instance, it is planned to verify strategic offensive weapons cuts—namely, strategic bomber and ICBM bases—using satellites forming part of national space monitoring systems or the international space monitoring systems proposed by the USSR and France.

However, there is currently no system for monitoring submarines. U.S. specialists believe that the country—the United States or the USSR—which is first to create a space-based submarine detection system will gain military superiority. They are analyzing how to use the results of Soviet and U.S. experiments in space-based oceanology to solve this problem.

It is obvious that competition to acquire such space systems tends to increase international instability. An undesirable development of scientific research in the sphere of oceanology could be prevented if such research were placed within the context of international cooperation. This would make it possible to set up within the framework of the international space organization proposed by the USSR a corresponding international system which would provide for space-based oceanography and verify the next stage of strategic offensive arms cuts, when strategic submarines would be reduced.

A similar decision is also possible in the sphere of space-based ABM defense positions, whose capabilities in a global conflict are being questioned in both the USSR and the United States. But what if the conflict is not global? What if we are talking about guarantees against accidental launches or, above all, missile launches by extremist groups? Such a limited system including ground- and space-based positions for combating non-massed [nemassovyy] missile launches is within the bounds of feasible technical solutions.

Unfortunately, we are still insufficiently aware that progress in military hardware is making particularly dangerous weapons, including missiles and nuclear warheads, increasingly accessible to extremists. Not for nothing was the United States so worried about the danger of Stinger missiles supplied to the Afghan opposition falling into terrorist hands. Bearing in mind that there are such dangerous targets for "missile" extremism

as nuclear power stations or major chemical plants whose destruction would have global tragic consequences, it is necessary to take corresponding international "antimissile" measures or we will live in continual fear of the fantasies of both big-time and small-time extremists.

The submission of such radical proposals on cooperation—as well as developing previously submitted Soviet and U.S. proposals—will promote the expansion of the zone of confidence and the transition from a "balance of terror" to a "balance of trust" and cooperation on a global scale, without which the ice of the "cold war" will never finally melt. In this sense the recent joint experiment staged aboard Black Sea Fleet vessels is very encouraging.

Academician Avduyevskiy Comments on Space Program Secrecy, Management Problems

18660187 Moscow OGONEK in Russian No 24, Jun 89 pp 6-8

[Interview with Academician Vsevolod Sergeyevich Avduyevskiy, chairman of the Gagarin Committee and the organizatonal committee for the Gagarin Readings, under the rubric "Perestroyka: A Spot Check": "Space: Does It Turn a Profit?"; first paragraph is introductory paragraph in source.]

[Text] **Are Earth satellites, orbital stations, and other such spacecraft worth the money invested in them? Why isn't everything going well on the "interplanetary front"? Why are there lags? When will the veil of secrecy be lifted from our space programs? Is it worth continuing space research on this scale, or would it be more sensible to transfer some of those funds to the development of earthly needs? These vitally important problems are discussed by Academician V. S. Avduyevskiy, chairman of the Gagarin committee and the organizing committee for scientific Gagarin readings, and OGONEK correspondent Vanda Beletskaya.**

Vsevolod Sergeyevich, is it true that after the launch of the first Soviet earth satellite, after our brilliant successes in the study of space which astounded the world, the Nobel committee asked for the names of the scientists and designers who had made the launch possible, to award them the Nobel prize, and we would not disclose their names?

There was talk of that. The launch of the first satellite, which opened the space age, was scientific work of Nobel stature, there is no doubt about that. The chief designers of the first spacecraft and the chief theoretician (primarily, Sergey Pavlovich Korolev and Mstislav Vsevolodovich Keldysh) could have received such a great prize. But back then, that work was secret...

Which, under such circumstances, is completely understandable. But sometimes we make inaccessible to the press purely scientific research. Is the notion of a "scientific secret" lawful?

Of course not. A secret may be a state secret, a military secret, or a commercial secret, of course, but never a scientific secret. I am certain that one of the reasons that the Soviet Union is gradually losing its lead in the conquest of space, as well as in the general development of scientific and technological potential, is an erroneous concept of secrecy, which leads to isolation from world science.

But even within our country we have scattered science among the different departments, rendering it infertile. In addition to academy institutes, we have many institutes of higher learning, universities, departmental scientific research institutes, and secret enterprises, where scientists are also working on, among other things, fundamental problems of science. Sometimes their research is unknown no only to the scientists of the world, but also to scientists of our own country. Which means we lose international prestige, along with prizes and discoveries. Science is like a chain reaction: a good result always generates a new success.

Nowadays we often "keep secret" things that are already known to our rivals, who are passing us at the crossroads of space. We conceal scientific results from ourselves—from our industry and from the people of our country. Thus, redundant research is done, and it is impossible to put the fruits of scientific labor into practice. Invaluable scientific and technical capital is often buried alive in safes, in reports that are "for official use only." And, unfortunately, this defective practice primarily concerns the space research itself that is carried out by and large not in academy institutes, where some information still gets out, but in departmental scientific research institutes and secret design bureaus.

Information on scientific research must be supplied so that scientists know who personally is working on what problem, and where. As for the results of research and the development of new technologies and materials (I'm not referring to purely defense work—that work has its own rules) which should be concealed for commercial considerations, there should be a clearly defined period of one, two, or three years, after which the results are published in the open press and may be transferred or sold to other organizations.

Much needs to be reexamined so that glasnost can become an organic part of the scientific and public life of the country "at all levels," as they say now. Perestroyka demands this. But it is important to not drown in useless, fancy phrases; instead, we must advance constructive suggestions and, most important, begin to put them into practice.

It seems to me that the recent Gagarin lectures could be seen, to some extent, as the beginning of the implementation of such constructive suggestions.

The authors of much-celebrated space projects stepped forward and frankly discussed the difficulties and drawbacks of the programs, something we have long been unaccustomed to. I noticed one seemingly insignificant

detail: the words "Valid upon presentation of document" were missing from the invitation itself. In a word, "the ice is broken."

The ice has been broken, yes, broken. We are hoping to attract as much attention as possible to the Gagarin lectures from scientists, cosmonauts, the public, and students of institutes of higher learning, and we want to invite specialists from abroad (this could never have been done earlier).

I am worried that the space science research institutes and design bureaus are catastrophically outdated. I remember in 1946, when Academician Mstislav Vsevolodovich Keldysh, who had already produced outstanding results in mechanics and mathematics, was appointed director of our scientific research institute, and Academician Sergey Pavlovich Korolev, already a famous rocket scientist by then, came to us. They seemed so old to us. Keldysh was 35 then, no more. Sergey Pavlovich was about 40...

Now interest in space research and the creation of spacecraft has declined among the young people in institutes of higher learning. I hope that the Space Science Society which we want to create will help to wake up that interest again. The society will be an open association of scientists, cosmonauts, designers, and technicians. At working sessions and conferences we will be able to discuss problems in the development of the space program. We will invite a wide range of people to the sessions—people's deputies, economists, students, instructors at institutes of higher learning, and, of course, journalists. The public will become full-fledged participants in the appraisal of space programs. The pluralism of opinions at these sessions, the complete openness, and glasnost will be in the spirit of perestroyka.

The Space Society should be given the authority to enter into negotiations with foreign scientists and public organizations, to invite specialists to visit us, and to go on science trips to become acquainted with the space research of other countries. In a word, it should be an informal intermediary in the international relations of specialists associated with interplanetary space research and the development of spacecraft.

It has great promise. But, Vsevolod Sergeyevich, you know, of course, that many people's deputies inserted a point in their election platforms that called for a reduction of funds for space research. Do you agree with them?

I am in complete agreement with them on the fact that matters in this field are not coming along well. The way space researche itself is set up needs to be changed radically; by and large, it needs to be converted to a commercial basis. But I am vehemently opposed to reducing allocated funds. They don't amount to much, and it would be a short-sighted decision, one not well thought out. Our economy would not receive even temporary benefits from it.

But you wouldn't deny that we are far from "the first in the world" in the conquest of space, that we have lost our lead?

I wouldn't deny it, but I don't agree with the word "far": the Buran system is, without a doubt, in the front ranks. Just as you probably wouldn't insist that we have had great successes everywhere, except in space research, where we have fallen behind...This field must not be torn from the overall development of the country, especially since all space equipment is made completely from domestic equipment, our materials, our elemental base. And that we have fallen behind, for example, in the computer technology, which is also necessary for space research, has been written about more than once. I would say something different: It is surprising that we have had such a brilliant success as Buran, that we are still managing to save face in space research, that the developed capitalist countries are collaborating with us on equal terms...Even despite the Phobos failure, which was extremely distressing. It was a very advanced, state-of-the-art, fundamentally new interplanetary spacecraft.

And in the beginning, everything was going according to program. Unique material about interplanetary space, Mars, and its satellite Phobos was sent to Earth. The coordinates of Phobos were refined considerably. The spacecraft provided magnificent photographs that, in themselves, are a scientific treasure. In the morning, I personally observed the clear pictures obtained from Phobos. The evening session began. The craft turned to Phobos and began to take pictures. Then it turned to Earth and should have sent the information, but it did not make the link with Earth...

It was announced on television that the last photographs showed a shadow like that from a spindle-shaped object. The Ogonek editorial office received a pile of letters asking if this were not a ship of extraterrestrial creatures and if it had not disrupted the communications with Phobos.

I don't think it was the ill will of extraterrestrials. Careful analysis is now being done. Some specialists think it is Phobos's shadow, others think it is a shadow from martian clouds. After all, surface contours can be seen through the shadow. I too think the shadow is from clouds. It is vexing that Phobos fell silent, leaving us with this riddle.

Why is it that in the years of a command-administrative system, which we criticize so much, we had an unbroken string of successes in space, and now that we have celebrated pluralism and democracy, failures and accidents have begun to happen?

Our past victories in the study of space were not because of the command-administrative system, they were in spite of it. And who told you the string was "unbroken"? It's not more accidents that we have—it's more glasnost. A heavy price was paid for our victories of yesterday and yesteryear...When Korolev made a rocket to launch the first satellite, there were accidents, and there were explosions. So many rockets "went over the hill," as they say.

Then we lost, as you no doubt remember, Salyut-1, and there were problems with Venera...

We also survived true tragedies, when Komarov died during landing, when Dobrovolskiy, Volkov, and Patsayev died during descent...Thank God we now have no human victims.

However, you are completely right that we are lagging further behind in space. This field of research needs perestroyka. Let us begin with the fact that money loves to be counted. Something you can collect a hefty sum for is not something to be locked in secret safes or left to gather dust on a shelf in the Priroda State Center. We are horribly slow ...and maybe even proud, eh? Why, for example, do all who want to go into space go for free? It costs money. We work in orbit together, we bear the expenses together. I understand people who were talking about reducing the budget for space research, although I do not agree with them. Of course the space programs should be published, and then discussed by specialists in industry, the USSR Academy of Sciences, and the public—in the Space Science Society, for example. I think that it would be more correct to fund the space program with a separate line of the budget, as in the United States, for example, where the NASA budget is approved by Congress. It would be clear how much space costs. Then there would be people responsible for the expenditure of funds, and they would be more cautious about the money when they're concluding a contract.

And if the distribution of the budget were up to you, if you were the "chief space director," how would you defend your positions?

Well, I wouldn't want to be the "chief space director," I like my work—both the public work and the scientific work. But I do have an opinion on this.

First of all, I would turn the deputies' attention to our hole-filled economy, into which, almost like a black hole in space, billions of the nation's rubles disappear, giving us nothing in return. Such an economy devours money allotted for Buran and Phobos, and for all our Prognoz and Foton spacecraft, and doesn't choke on it. No matter how much you give it, it's not enough. This has been ascertained more than once. And the prices for goods and products have risen, and construction has been cheapened to the point of idiocy, and less money has been given to science, just to help the economy. But the standard of living in the country has dropped steadily.

Then I would remind them that because of our ill-advised development of Siberia, especially Tyumen, we lost considerably more money that was spent on all of space science. I would add to the lost billions of public monies those funds spent on laying rusting gas pipeline across the entire country; on the dragged-out, ill-considered "construction job of the century"—the Baykal-Amur trunk rail line; and, finally, on the development of the "project of the century"—the changing of the course of rivers, which, fortunately, was not carried out. So, before a decision is made to approve or reject a project, a careful, thorough, independent analysis is needed, as well as a scientific forecast of what carrying out the project will do for us and where it will lead. Hasty decisions chasing after supposedly instant benefits have more than once in our memory produced losses, and not only of funds, but also of morals and morale. And losses in morale are the hardest to replace.

Now let's talk about space research itself, its cost, its importance, and the benefits from space research for society.

First, to immediately put an end to the talk of the heavy burden of space science on the shoulders of the economy, let me say that space research pays for itself. It's another matter that society's benefit from space science could be a hundred times greater if it weren't for our slowness and mismanagement.

Every day, each of us enjoys a little of the fruits of space research. Thanks to those satellites, there are no more god-forsaken places where there is no television, telephone, and other communications. According to the USSR Ministry of Communication, the economic impact last year of the use of the Orbita, Moskva, and Ekran systems alone was 540 million rubles.

Television and radio, telephone and telegraph, the transfer of information, the compilation of maps of the surface of the Earth, the prediction of weather—these are just a few of the items on the list of the terrestrial business of spacecraft. Consideration of weather forecasts decreases possible damage to the economy due to natural disasters, and each year it has an economic effect of up to 700 million rubles. Add 350 million obtained each year from the in-orbit study of the natural resources of the country.

Not everything can be counted. For example, what price do you put on the 1,700 human lives saved because of the space search-and-rescue service for disaster survivors? How do you reckon the economic impact of the Tsikada system of satellites, which makes it possible for ocean-going ships to determine their location with an accuracy of up to 100 meters? What dollar figure do you put on the SOS the cosmonauts sent from orbit after observing the ecological situation on our small planet?

I named only the first things that came to mind...

No one on Earth can seriously say "I don't care how life arose on our planet. I don't want to know how it was in the past, or how it will be in the future, and it makes no difference to me what's happening on Mars and Venus." And it is information obtained from space vehicles that has turned inside-out what we know about the universe and about Earth. The process of learning must not stop.

Let us turn to more tangible examples—to space technologies. Experiments have been conducted in weightlessness to obtain new materials, monocrystals, superconductors, medical and biological preparations, medicines, and vaccines. In a few years, we will be

producing in space materials and medical preparations worth 3 to 5 billion rubles a year.

But compared to what we could gain from studying space, this is insignificant. Space research in itself accelerates progress. In the course of its developments, new technologies, new fire-resistant superhard materials, heat-shielding carbon-carbon composites and ceramic materials, and new means of producing tungsten, beryllium, and molybdenium alloys are born at the same time. And instead of using this invaluable treasure to increase the industrial potential of the country, we, like the covetous knight, store it in secret safes, neither using it in our own country, nor selling patents abroad. The Americans, for example, spent 24 billion dollars on the Apollo program, but their industry earned about 300 billion in space patents.

But can we now sell patents on the new technologies and means of obtaining fire-resistant and super-strong materials developed in the course of work on Buran, while it is still a novelty, the last word in space technology Or will we again hide everything in safes?

Today, fortunately, is a different time. Back from space, Buran is going to France, to go on exhibit. Our representatives are expecting commercial deals. But not everything can be sold as raw material abroad, as in semi-colonial countries.

Of course, results produced during work in the creation of Buran should be given first to our industry, although this requires, of course, serious transformation of many enterprises.

Right now, in general, transferring as much as possible of the results of space research and rocket technology to the economy is extremely important. I am studying this problem in particular. In its solution I see, on the one hand, a means of overcoming the scientific and technical backwardness of the country and, on the other, a real possibility of extracting a great deal of profit from space research and scientific and technical achievements of other defense sectors.

In this sense the question of the interaction of fundamental and applied science is timely. What is your point of view?

I have already complained that the living body of science has been dismembered and divided among the departments. But that's not all. Science has been formally divided into fundamental (real science) and applied (science of a lower category). Scientists have been divided into theoreticians (the elite) and experimenters (those who are not as good), and various designers, engineers, and developers there don't count at all. I'm being facetious, of course, and exaggerating things, but to think that "real" science is concentrated only in the Academy of Sciences is mindless; science has no departmental boundaries. Meanwhile, at the conference for electing the people's deputies of the Academy, it was suggested that even a public organization—the Union of Scientists—be formed only of those working in academy institutes.

The Institute of Mechanical Engineering, where you work, is also an academy institute.

That means no one can accuse me of subjectivity and bias. How, for example, could TsAGI—the internationally known Central Aerohydrodynamic Institute, where Zhukovskiy, Chaplygin, Tupolev, and Keldysh worked—be worse than any academy institute? Ninety percent of space research is done outside the Academy of Sciences system, and in my opinion, the Academy is not all that interested in it—not in the publication of the scientific work, and even less in the introduction of achievements into practice. There are such institutes in the space industry, in the nuclear industry, in and practically all other sectors of industry.

Everywhere else in the world there is no division of science into academy and nonacademy. But great scientific discoveries are nevertheless made, and others have far more Nobel laureates than we do. That, without a doubt, is the criterion for the level of scientific work.

Let us take the latest epoch-making discovery—superconductivity at higher temperatures—and the quite recent, interesting finding of cold fusion in the electrolysis of heavy water. The first work was done in Switzerland by Müller and Bednorz, Nobel laureates; the second was done in the United States by Fleischmann and Pons, who were studying electrochemistry. Both discoveries promise a revolution in science, industry, and power engineering. How do you categorize them—as fundamental, pure science, or, for all that, as applied science? The results are, all things being equal, fundamental. In life everything is more complex, everything interconnects.

If you let your imagination go a little, you might hope that the energy liberated by cold nuclear fusion (if it is confirmed, of course) will compete with solar batteries in space. In weightlessness, Buran could be used to create the ideal palladium crystals needed for the cold fusion reaction. Cold fusion could lead to a revolution in science and technology, not to mention power engineering.

Why do I say this? Our "academy" scientists, working, of course, for fundamental science, say that they could have easily made both of these discoveries themselves, they were very close, but...It seems to me that this "but" comes precisely from their contempt for experimental, applied research and real benefit. Even in space research we often forget about this.

Vsevolod Sergeyevich, in the beginning of the conversation you noted that an organizational perestroyka is needed in space research. Do you have your own program?

Program...that word sounds too big. I have simply a few thoughts, my opinion, which, of course, is not the last

word on the matter. I have already revealed some points of my "program," as you call it.

In space research, it is important to do as much work as possible on a commercial basis. However, business doesn't tolerate delay. For that reason, the directors of Glavkosmos and the Priroda State Center should be given the proper authority.

There is another common disease among us—the tendency to macromania. It would be more efficient to break up the gigantic enterprises we have for rockets and spacecraft into smaller units (Korolev had a considerably smaller design bureau).

In addition to a General designer, such enterprises need a director-manager who handles space business.

What else? Organizationally speaking, it is still difficult to do that in our country, but I would use the experience of the Americans: create temporary groups of specialists for the development of a specific scientific program, to create this or that spacecraft. That is how the Americans made their Vikings. A contract was signed with designers and the necessary specialists for nine years, regardless of where in the country they lived and worked. When the program was successfully completed, the group was disbanded.

It would be useful if at least some of the scientific instruments for the orbital stations, Buran, and other spacecraft were made on a competitive basis, or even if foreign firms and specialists and developers from other countries were allowed to participate in the competition. That would eliminate the monopoly.

Otherwise, our space research will really fall catastrophically behind, and the people's deputies will be faced with the difficult decision of whether to discontinue its funding.

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